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AGASSIZ AT PENIKESE.

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AGASSIZ was above all else a teacher. His mission in America was that of a teacher of science—of science in the broadest sense as the orderly arrangement of all human knowledge. He would teach men to know, not simply to remember or to guess. He believed that men in all walks of life would be more useful and more successful through the thorough development of the powers of observation and judgment. He would have the student trained through contact with real things, not merely exercised in the recollection of the book descriptions of things. "If you study Nature in books," he said, "when you go out of doors you can not find her."

Agassiz was once asked to write a text-book in zoölogy for the use of schools and colleges. Of this he said: "I told the publishers that I was not the man to do that sort of thing, and I told them, too, that the less of that sort of thing which is done the better. It is not school-books we want, it is students. The book of Nature is always open, and all that I can do or say shall be to lead young people to study that book, and not to pin their faith to any other."

He taught natural history in Harvard College as no other man had taught in America before. He was "the best friend that ever student had," because the most genial and kindly. Cambridge people used to say that one had "less need of an overcoat in passing Agassiz's house" than any other in that city.

In the interest of popular education as well as of scientific research, Agassiz laid the foundation of the Museum of Comparative Zoölogy. Here, in the face of all sorts of discouragements,

he worked with wonderful zeal, which showed its results in the success of everything with which he had to do.

Of the older teachers of biology in America, the men who were born between 1830 and 1850, nearly all who have reached eminence have been at one time or another pupils of Agassiz. The names of Le Conte, Hartt, Shaler, Scudder, Wilder, Putnam, Packard, Clark, Alexander Agassiz, Morse, Lyman, Brooks, Whitman, Garman, Faxon, Fewkes, Minot, and many others not less worthily known, come to our thoughts at once as evidence of this statement.

Even as late as 1873, when Agassiz died, the Museum of Comparative Zoölogy was almost the only school in America where the eager student of natural history could find the work he wanted. The colleges generally taught only the elements of any of the sciences. Twenty years ago original research was scarcely considered as among the functions of the American college. Such investigators as America had were for the most part outside of the colleges, or at the best carrying on their investigations in time stolen from the drudgery of the class-room. One of the greatest of American astronomers was kept for forty years teaching algebra and geometry, with never a student far enough advanced to realize the real work of his teacher. And this case was typical of hundreds before the university spirit was kindled in American schools. That this spirit was kindled in Harvard forty years ago was due in the greatest measure to Agassiz's influence. It was here that graduate instruction in science in America practically began. In an important sense the Museum of Comparative Zoölogy was the first American university.

Notwithstanding the great usefulness of the museum and the broad influence of its teachers, Agassiz was not fully satisfied. The audience he reached was still too small. Throughout the country the great body of teachers of science went on in the old mechanical way. On these he was able to exert no influence. The boys and girls still kept up the humdrum recitations from worthless text-books. They got their lessons from the book, recited them from memory, and no more came into contact with Nature than they would if no animals or plants or rocks existed on this side of the planet Jupiter.

It was to remedy this state of things that Agassiz conceived, in 1872, the idea of a scientific "camp-meeting," where the workers and the teachers might meet together—a summer school of observation where the teachers should be trained to see Nature for themselves and teach others how to see it.

The first plan suggested was that of calling the teachers of the country together for a summer outing on the island of Nantucket. Before the site was chosen, Mr. John Anderson, a wealthy tobacco

merchant in New York city, offered to Agassiz the use of his island of Penikese, together with a large yacht and an endowment of fifty thousand dollars in money, if he would permanently locate this scientific "camp-meeting" on the island. Thus was founded the Anderson School of Natural History on the island of Penikese.

Penikese is a little island containing about sixty acres of very rocky ground, a pile of stones, with intervals of soil. It is the last and least of the Elizabeth Islands, lying to the south of Buzzard's Bay, on the south coast of Massachusetts. The whole cluster was once a great terminal moraine of rocks and rubbish of all sorts, brought down from the mainland by some ancient glacier, and by it dropped into the ocean off the heel of Cape Cod. The sea has broken up the moraine into eight little islands by wearing tide channels between hill and hill. The names of these islands are recorded in the jingle which the children of that region learn before they go to school:

> "Naushon, Nonamesset, Uncatena, and Wepecket,
> Nashawena, Pesquinese, Cuttyhunk, and Penikese."

And Penikese, last and smallest of them, lies, a little forgotten speck, out in the ocean, eighteen miles south of New Bedford. It contains two hills, joined together by a narrow isthmus, a little harbor, a farm-house, a flag-staff, a barn, a willow tree, and a flock of sheep. And here Agassiz founded his school. This was in the month of June in the year 1873.

From the many hundred applicants who sent in their names as soon as the school was made public Agassiz chose fifty—thirty men, twenty women—teachers, students, and naturalists of various grades from all parts of the country. This practical recognition of coeducation was criticised by many of Agassiz's friends, trained in the monastic schools of New England, but the results soon justified the decision. These fifty teachers should be trained so far as he could train them in right methods of work. They should carry into their schools his own views of scientific teaching. Then each of these schools would become in its time a center of help to others, until the influence toward real work in science should spread throughout our educational system.

None of us will ever forget his first sight of Agassiz. We had come down from New Bedford in a little tug-boat in the early morning, and Agassiz met us at the landing-place on the island. He was standing almost alone on the little wharf, and his great face beamed with pleasure. For this summer school, the thought of his old age, might be the crowning work of his lifetime. Who could foresee what might come from the efforts of fifty men and women, teachers of science, each striving to do his work in the

best possible way? His thoughts and hopes rose to expectations higher than any of us then understood.

His tall, robust figure, broad shoulders bending a little under the weight of years, his large round face lit up by kindly dark-brown eyes, his cheery smile, the enthusiastic tones of his voice, all these entered into our first as well as our last impressions of Agassiz. He greeted us with great warmth as we landed. He looked into our faces to justify himself in making choice of us among the many whom he might have chosen.

The roll of the Anderson School has never been published, and I can only restore a part of it from memory. Among those whose names come to my mind as I write are Dr. Charles O. Whitman, now of Clark University; Dr. William K. Brooks, of Johns Hopkins; Dr. Frank H. Snow, now Chancellor of the University of Kansas; Dr. W. O. Crosby, of the Boston Society of Natural History, then a boy from Colorado interested in rocks and minerals; Samuel Garman, Walter Faxon, Walter Fewkes, and Charles Sedgwick Minot, all of them still connected with the work at Cambridge; Ernest Ingersoll, then just beginning his literary work; Prof. Scott, of the Normal School at Westfield; Prof. Stowell, of the school at Cortland; Prof. Apgar, of Trenton, N. J.; Prof. Fernald, of Maine; Miss Susan Hallowell, of Wellesley College; Miss Mary Beaman (Mrs. Joralemon); Mr. E. A. Gastman, of Illinois; and other well-known instructors. With these was the veteran teacher of botany at Mount Holyoke Seminary, Miss Lydia W. Shattuck, with her pupil and associate, Miss Susan Bowen. Prof. H. H. Straight and his bride, both then teachers in the State Normal School at Oswego, were also with us. These four, whom all of us loved and respected, were the first of our number to be claimed by death.

Among our teachers, besides Agassiz, were Burt G. Wilder, Edward S. Morse, Alfred Mayer, Frederick W. Putnam, then young men of growing fame, with Arnold Guyot and Count Pourtalès, early associates of Agassiz, already in the fullness of years. Mrs. Agassiz was present at every lecture, note-book in hand, and her genial personality did much to bind the company together.

The old barn on the island had been hastily converted into a dining-hall and lecture-room. A new floor had been put in, but the doors and walls remained unchanged, and the swallows' nests were undisturbed under the eaves. The sheep had been turned out, the horse-stalls were changed to a kitchen, and on the floor of the barn, instead of the hay-wagon, were placed three long tables. At the head of one of these sat Agassiz. At his right hand always stood a movable blackboard, for he seldom spoke without a piece of chalk in his hand. He would often give us a

lecture while we sat at the table, frequently about some fish or other creature, the remains of which still lay beside our plates.

Our second day upon the island was memorable above all others. Its striking incident has passed into literature in the poem of Whittier, "The Prayer of Agassiz."

When the morning meal was over, Agassiz arose in his place and spoke, as only he could speak, of his purpose in calling us together. The swallows flew in and out of the building in the soft June air, for they did not know that it was no longer a barn but a temple. Some of them almost grazed his shoulder as he spoke to us of the needs of the people for better education. He told us how these needs could be met, and of the results which might come to America from the training and consecration of fifty teachers.

This was to him no ordinary school, still less an idle summer's outing, but a mission work of the greatest importance. He spoke with intense earnestness, and all his words were filled with that deep religious feeling so characteristic of all his thoughts. For to Agassiz each natural object was a thought of God, and trifling with God's truth as expressed in Nature was the basest of sacrilege.

What Agassiz said that morning can never be said again. No reporter took his language, and no one could call back the charm of his manner or the impressiveness of his zeal and faith.

At the end he said, "I would not have any man to pray for me now," and that he and each of us would utter his own prayer in silence. What he meant by this was that no one could pray in his stead. No public prayer could take the place of the prayer which each of us would frame for himself. Whittier says:

> "Even the careless heart was moved,
> And the doubting gave assent
> With a gesture reverent
> To the Master well beloved.
> As thin mists are glorified
> By the light they can not hide,
> All who gazed upon him saw,
> Through its veil of tender awe,
> How his face was still uplit
> By the old sweet look of it;
> Hopeful, trustful, full of cheer
> And the love that casts out fear."

And the summer went on with its succession of joyous mornings, beautiful days, and calm nights, with every charm of sea and sky, the master with us all day long, ever ready to speak words of help and encouragement, ever ready to give us from his own stock of learning. The boundless enthusiasm which sur-

rounded him like an atmosphere, and which sometimes gave the appearance of great achievement to the commonest things, was never lacking.

Essentially Latin in his nature, he was always picturesque in his words and his work. He delighted in the love and approbation of his students and his friends, and the influence of his personality sometimes gave his opinions weight beyond the value of the investigations on which they were based. With no other investigator have the work and the man been so identified as with Agassiz. No other of the great workers has been equally great as a teacher. His greatest work in science was his influence on other men.

In an old note-book of those days I find fragments of some of his talks to teachers at Penikese. From this note-book I take some paragraphs, just as I find them written there:

"Never try to teach what you do not yourself know and know well. If your school board insist on your teaching anything and everything, decline firmly to do it. It is an imposition alike on pupils and teacher to teach that which he does not know. Those teachers who are strong enough should squarely refuse to do such work. This much-needed reform is already beginning in our colleges, and I hope it will continue. It is a relic of mediæval times, this idea of professing everything. When teachers begin to decline work which they can not do well, improvements begin to come in. If one will be a successful teacher, he must firmly refuse work which he can not do successfully.

"It is a false idea to suppose that everybody is competent to learn or to teach everything. Would our great artists have succeeded equally well in Greek or calculus? A smattering of everything is worth little. It is a fallacy to suppose that an encyclopædic knowledge is desirable. The mind is made strong not through much learning, but by the thorough possession of something."

"Lay aside all conceit. Learn to read the book of Nature for yourself. Those who have succeeded best have followed for years some slim thread which has once in a while broadened out and disclosed some treasure worth a life-long search."

"A man can not be professor of zoölogy on one day and of chemistry on the next, and do good work in both. As in a concert all are musicians—one plays one instrument, and one another, but none all in perfection."

"You can not do without one specialty. You must have some base-line to measure the work and attainments of others. For a general view of the subject, study the history of the sciences. Broad knowledge of all Nature has been the possession of no naturalist except Humboldt, and general relations constituted his specialty."

"Select such subjects that your pupils can not walk without seeing them. Train your pupils to be observers, and have them provided with the specimens about which you speak. If you can find nothing better, take a house-fly or a cricket, and let each one hold a specimen and examine it as you talk."

"In 1847 I gave an address at Newton, Mass., before a Teachers' Institute conducted by Horace Mann. My subject was grasshoppers. I passed around a large jar of these insects, and made every teacher take one and hold it while I was speaking. If any one dropped the insect, I stopped till he picked it up. This was at that time a great innovation, and excited much laughter and derision. There can be no true progress in the teaching of natural science until such methods become general."

"There is no part of the country where in the summer you can not get a sufficient supply of the best specimens. Teach your children to bring them in yourselves. Take your text from the brooks, not from the booksellers. It is better to have a few forms well known than to teach a little about many hundred species. Better a dozen specimens thoroughly studied as the result of the first year's work, than to have two thousand dollars' worth of shells and corals bought from a curiosity-shop. The dozen animals would be your own."

"You* will find the same elements of instruction all about you wherever you may be teaching. You can take your classes out and give them the same lessons, and lead them up to the same subjects you are yourselves studying here. And this method of teaching children is so natural, so suggestive, so true. That is the charm of teaching from Nature herself. No one can warp her to suit his own views. She brings us back to absolute truth as often as we wander."

"The study of Nature is an intercourse with the highest mind. You should never trifle with Nature. At the lowest her works are the works of the highest powers, the highest something in whatever way we may look at it."

"A laboratory of natural history is a sanctuary where nothing profane should be tolerated. I feel less agony at improprieties in churches than in a scientific laboratory."

"In Europe I have been accused of taking my scientific ideas from the Church. In America I have been called a heretic because I will not let my church-going friends pat me on the head."

Of all these lectures the most valuable and the most charming were those on the glaciers. In these the master spoke, and every rock on our island was a mute witness to the truth of his words.

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* In this paragraph, quoted by Mrs. Agassiz (Life and Letters of Agassiz, p. 775), I have adopted the wording as given by her.

He often talked to us of the Darwinian theory, to which in all its forms he was most earnestly opposed. Agassiz was essentially an idealist. All his investigations were to him not studies of animals or plants as such, but of the divine plans of which their structures are the expression. "That earthly form was the cover of spirit was to him a truth at once fundamental and self-evident." The work of the student was to search out the thoughts of God, and as well as may be to think them over again. To Agassiz these divine thoughts were especially embodied in the relations of animals to each other. The species was the thought-unit, the individual reproduction of the thought in the divine mind at the moment of the creation of the first one of the series which represents the species. The marvel of the affinity of structure—of unity of plan in creatures widely diverse in habits and outward appearance—was to him a result of the association of ideas in the divine mind, an illustration of divine many-sidedness. To Darwin these same relations would illustrate the force of heredity acting under diverse conditions of environment.

Agassiz had no sympathy with the prejudices worked upon by weak and foolish men in opposition to Darwinism. He believed in the absolute freedom of science; that no power on earth can give answers beforehand to the questions which men of science endeavor to solve. Of this I can give no better evidence than the fact that every one of the men specially trained by him has joined the ranks of the evolutionists. He would teach them to think for themselves, not to think as he did.

The strain of the summer was heavier than we knew. Before the school came to an end, those who were nearest him felt that the effort was to be his last. His physician told him that he must not work, must not think. But all his life he had done nothing else. To stop was impossible, for with his temperament there was the sole choice between activity and death.

And in December the end came. In the words of one of his old students, Theodore Lyman, "We buried him from the chapel that stands among the college elms. The students laid a wreath of laurel on his bier, and their manly voices sang a requiem. For he had been a student all his life long, and when he died he was younger than any of them."

The next summer, the students of the first year came together at Penikese, and many eager new faces were with them. Wise and skillful teachers were present, but Agassiz was not there, and the sense of loss was felt above everything else. The life was gone out from Penikese, and at the end of the summer the authorities of the museum closed the doors of the Anderson School forever. The buildings stand on the island, just as we left them in 1874, a single old sea-captain in charge of them all these years, until last

winter, when he was lost in a storm. The blackboards in the lecture-hall* still bear the inscriptions left on them by the students and taken from the words of the master:

"STUDY NATURE, NOT BOOKS."

"BE NOT AFRAID TO SAY NO.

"A LABORATORY IS A SANCTUARY WHICH NOTHING PROFANE SHOULD ENTER."

But, while the island of Penikese is deserted, the impulse which came from Agassiz's work there still lives, and is felt in every field of American science.

With all appreciation of the rich streams which in late years have come to us from Germany, it is still true that "the school of all schools which has most influence on scientific teaching in America was held in an old barn on an uninhabited island some eighteen miles from the shore. It lasted but three months, and in effect it had but one teacher. The school at Penikese existed in the personal presence of Agassiz; when he died it vanished!"

NEW CHAPTERS IN THE WARFARE OF SCIENCE.

XV. ASTRONOMY.

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PART II.

WHILE news of triumphant attacks upon him and upon the truth he had established were coming in from all parts of Europe, Galileo prepared a careful treatise in the form of a dialogue, exhibiting the arguments for and against the Copernican and Ptolemaic systems, and offered to submit to any conditions that the Church tribunals might impose if they would allow it to be printed. At last, after discussions which extended through eight years, they consented, imposing a humiliating condition;—the preface written in accordance with the ideas of Father Ricciardi, Master of the Sacred Palace, and signed by Galileo, in which the Copernican theory was virtually exhibited as a play of the imagination, and not at all as opposed to the Ptolemaic doctrine reasserted in 1616 by the Inquisition under the direction of Pope Paul V.†

* According to Dr. Carl H. Eigenmann, who has lately visited the island.

† As to the general style of the attacks, see Fromundus's book, cited above, *passim*, but especially the heading of chapter vi, and the argument in chapters x and xi. For interesting reference to one of Fromundus's arguments, showing, by a mixture of mathematics and theology, that the earth is the center of the universe, see Quetelet, Histoire des Sciences mathématiques et physiques, Bruxelles, 1864, p. 170; also, Mädler, Geschichte der Astronomie, vol. i, p. 274.

This new work of Galileo—the "Dialogo"—appeared in 1632, and met with prodigious success. It put new weapons into the hands of the supporters of the Copernican theory. The pious preface was laughed at from one end of Europe to the other. This roused the enemy. The Jesuits, Dominicans, and the great majority of the clergy returned to the attack more violent than ever, and in the midst of them stood Pope Urban VIII, most bitter of all. His whole power was now thrown against Galileo. He was touched in two points: first, in his personal vanity, for Galileo had put his arguments into the mouth of one of the persons in the dialogue and their refutation into the mouth of another; but, above all, he was touched in his religious feelings. Again and again he insisted to all comers on the absolute and specific declarations of Holy Scripture, which prove that the sun and heavenly bodies revolve about the earth, and declared that to gainsay them is simply to dispute revelation. Certainly, if one ecclesiastic more than another ever seemed *not* under the care of the Spirit of Truth, it was Urban VIII in all this matter.

Herein was one of the greatest pieces of ill fortune that has ever befallen the older Church. Had Pope Urban been broad-minded and tolerant like Benedict XIV, or had he been taught moderation by adversity like Pius VII, or had he possessed the large scholarly qualities of Leo XIII, now reigning, the vast scandal of the Galileo case would never have burdened the Church: instead of devising endless quibbles and special pleadings to escape responsibility for this colossal blunder, its defenders could have claimed forever for the Church the glory of fearlessly initiating a great epoch in human thought.

But it was not so to be. Urban was not merely Pope, he was also a prince of the house of Barberini, and therefore doubly angry that his arguments had been publicly controverted.

The opening strategy of Galileo's enemies was to forbid the sale of his work; but this was soon seen to be unavailing, for the first edition had already been spread throughout Europe. Urban now became more angry than ever, and both Galileo and his works were placed in the hands of the Inquisition. In vain did the good Benedictine, Castelli, urge that Galileo was entirely respectful to the Church; in vain did he insist that "nothing that can be done can now hinder the earth from revolving." He was dismissed in disgrace, and Galileo was forced to appear in the presence of the dread tribunal without defender or adviser. There, as was so long concealed, but as is now fully revealed, he was menaced with torture again and again by express order of Pope Urban, and, as is also thoroughly established from the trial documents themselves, forced to abjure under threats, and subjected to imprisonment by command of the Pope; the Inquisition defer-

ring in this whole matter to the papal authority. All the long series of attempts made in the supposed interest of the Church to mystify these transactions have at last failed. The world knows now that Galileo was subjected certainly to indignity, to imprisonment, and to threats equivalent to torture, and was at last forced to pronounce publicly and on his knees his recantation, as follows:

"I, Galileo, being in my seventieth year, being a prisoner and on my knees, and before your Eminences, having before my eyes the Holy Gospel, which I touch with my hands, abjure, curse, and detest the error and the heresy of the movement of the earth." *

He was vanquished indeed, for he had been forced, in the face of all coming ages, to perjure himself. To complete his dishonor, he was obliged to swear that he would denounce to the Inquisition any other man of science whom he should discover to be supporting the "heresy of the motion of the earth."

Many have wondered at this abjuration, and on account of it have denied to Galileo the title of martyr. But let such gainsayers consider the circumstances. Here was an old man—one who had reached the allotted threescore years and ten, broken with disappointments, worn out with labors and cares, dragged from Florence to Rome, with the threat from the Pope himself that if he delayed he should be "brought in chains"; sick in body and mind, given over to his oppressors by the grand duke who ought to have protected him, and on his arrival in Rome threatened with torture. What the Inquisition was he knew well. He could remember but as yesterday the burning of Giordano Bruno in that same city for scientific and philosophic heresy; he could remember, too, that only eight years before this very time De Dominis, Archbishop of Spalatro, having been seized by the Inquisition for scientific and other heresies, had died in a dungeon, and that his body and his writings had been publicly burned.

To the end of his life, nay, after his life was ended, the persecution of Galileo was continued. He was kept in exile from his family, from his friends, from his noble employments, and held rigidly to his promise not to speak of his theory. When, in the midst of intense bodily sufferings from disease, and mental sufferings from calamities in his family, he besought some little liberty, he was met with threats of committal to a dungeon. When at

* For various utterances of Pope Urban against the Copernican theory at this period, see extracts from the original documents given by Gebler. For punishment of those who had shown some favor to Galileo, see various citations, and especially those from the Vatican manuscript, Gebler, p. 216. As to the text of the abjuration, see L'Epinois; also Polacco, *Anticopernicus*, etc., Venice, 1644; and for a discussion regarding its publication, see Favaro, Miscellanea Galileana, p. 804.

last a special commission had reported to the ecclesiastical authorities that he had become blind and wasted with disease and sorrow, he was allowed a little more liberty, but that little was hampered by close surveillance. He was forced to bear contemptible attacks on himself and on his works in silence; to see the men who had befriended him severely punished; Father Castelli banished; Ricciardi, the Master of the Sacred Palace, and Ciampoli, the papal secretary, thrown out of their positions by Pope Urban, and the Inquisitor at Florence reprimanded for having given permission to print Galileo's work. He lived to see the truths he had established carefully weeded out from all the Church colleges and universities in Europe, and when in a scientific work he happened to be spoken of as "renowned," the Inquisition ordered the substitution of the word "notorious." *

And now measures were taken to complete the destruction of the Copernican theory, with Galileo's proofs of it. On the 16th of June, 1633, the Holy Congregation, with the permission of the reigning Pope, ordered the sentence upon Galileo, and his recantation, to be sent to all the papal nuncios throughout Europe, as well as to all archbishops, bishops, and inquisitors in Italy; and this document gave orders that the sentence and abjuration be made known "to your vicars, that you and all professors of philosophy and mathematics may have knowledge of it, that they may know why we proceeded against the said Galileo, and recognize the gravity of his error, in order that they may avoid it, and thus not incur the penalties which they would have to suffer in case they fell into the same." †

As a consequence of this, the professors of mathematics and astronomy in various universities of Europe were assembled and these documents were read to them. To the theological authorities this gave great satisfaction; the Rector of the University of Douay, referring to the opinion of Galileo, wrote to the papal nuncio at Brussels, "the professors of our university are so opposed to this fanatical opinion that they have always held that it must be banished from the schools: in our English college at Douay this paradox has never been approved and never will be."

Still another step was taken: the Inquisitors were ordered, especially in Italy, not to permit the publication of a new edition of any of Galileo's works, nor of any similar writings. On the other hand, theologians were urged, now that Copernicus and

* It is not probable that torture in the ordinary sense was administered to Galileo, though it was threatened. See Th. Martin, Vie de Galilée, for a fair summing up of the case. For the substitution of the word "notorious" for "renowned" by order of the Inquisition, see Martin, p. 227.

† For a copy of this document, see Gebler, p. 269. As to the spread of this and similar documents notifying Europe of Galileo's condemnation, see Favaro, pp. 804, 805.

Galileo and Kepler were silenced, to reply to them with tongue and pen. Europe was flooded with these theological refutations of the Copernican system.

To make all complete, there was prefixed to the "Index" of the Church, forbidding "all writings which affirm the motion of the earth," a bull signed by the reigning Pope, which, by virtue of his infallibility as a divinely guided teacher in matters of faith and morals, clinched this condemnation into the consciences of the whole Christian world.

From the mass of books which appeared under the auspices of the Church immediately after the condemnation of Galileo, for the purpose of rooting out every vestige of the hated Copernican theory from the mind of the world, two may be taken as typical. The first of these was a work by Scipio Chiaramonti, dedicated to Cardinal Barberini. Among his arguments against the double motion of the earth may be cited the following:

"Animals, which move, have limbs and muscles; the earth has no limbs or muscles, therefore it does not move. It is angels who make Saturn, Jupiter, the sun, etc., turn round. If the earth revolves, it must also have an angel in the center to set it in motion; but only devils live there; it would therefore be a devil who would impart motion to the earth. . . .

"The planets, the sun, the fixed stars, all belong to one species—namely, that of stars—they therefore all move or all stand still. It seems, therefore, to be a grievous wrong to place the earth, which is a sink of impurity, among the heavenly bodies, which are pure and divine things."

The next, which I select from the mass of similar works, is the *Anticopernicus Catholicus* of Polacco. It was intended to deal a finishing stroke at Galileo's heresy.

In this it is declared: "The Scripture always represents the earth as at rest, and the sun and moon as in motion; or, if these latter bodies are ever represented as at rest, Scripture represents this as the result of a great miracle." . . .

"These writings must be prohibited, because they teach certain principles about the position and motion of the terrestrial globe repugnant to Holy Scripture and to the Catholic interpretation of it, not as hypotheses but as established facts. . . .

"It is possible to work with the hypotheses of Copernicus so as to explain many phenomena. . . . Yet it is not permitted to argue on his premises except to show their falsity."

Speaking of Galileo's book, Polacco says that it "smacked of Copernicanism," and that, "when this was shown to the Inquisition, Galileo was thrown into prison and was compelled to utterly abjure the baseness of this erroneous dogma."

As to the authority of the cardinals in their decree, Polacco

asserts that, since they are the "Pope's Council" and his "brothers," their work is one, except that the Pope is favored with special divine enlightenment.

Having shown that the authority of the Scriptures, of popes, and of cardinals is against the new astronomy, he gives a refutation based on physics. He asks: "If we concede the motion of the earth, why is it that an arrow shot into the air falls back to the same spot, while the earth and all things on it have, in the mean time, moved very rapidly toward the east? Who does not see that great confusion would result from this motion?"

Next he argues from metaphysics, as follows: "The Copernican theory of the earth's motion is against the nature of the earth itself, because the earth is not only cold but contains in itself the principle of cold; but cold is opposed to motion, and even destroys it—as is evident in animals, which become motionless when they become cold."

Finally, he clinches all with a piece of theological reasoning, as follows: "Since it can certainly be gathered from Scripture that the heavens move above the earth, and since a circular motion requires something immovable around which to move, . . . the earth is at the center of the universe."*

But any sketch of the warfare between theology and science in this field would be incomplete without some reference to the treatment of Galileo after his death. He had begged to be buried in his family tomb in Santa Croce; this request was denied. His friends wished to erect a monument over him; this, too, was refused. Pope Urban said to the ambassador Niccolini that "it would be an evil example for the world if such honors were rendered to a man who had been brought before the Roman Inquisition for an opinion so false and erroneous; who had communicated it to many others, and who had given so great a scandal to Christendom." In accordance, therefore, with the wish of the Pope and the orders of the Inquisition, Galileo was buried ignobly, apart from his family, without fitting ceremony, without monument, without epitaph. Not until forty years after did Pierrozzi dare write an inscription to be placed above his bones; not until a hundred years after did Nelli dare transfer his remains to a suitable position in Santa Croce, and erect a monument above them. Even then the old conscientious hostility burst forth: the Inquisition was besought to prevent such honors to "a man condemned for notorious errors"; and that tribunal refused to allow any epitaph to be placed above him which had not been submitted to its

* For Chiaramonti's book and selections given, see Gebler as above, p. 271. For Polacco, see his work as cited, especially Assertiones i, ii, vii, xi, xiii, lxxiii, clxxxvii, and others. The work is in the White Library at Cornell University. The date of it is 1644.

censorship. Nor has that old conscientious consistency in hatred yet fully relented: hardly a generation since has not seen some ecclesiastic like Marini or De Bonald or Rallaye or De Gabriac, suppressing evidence, or torturing expressions, or inventing theories to blacken the memory of Galileo and save the reputation of the Church. Nay, more, there are school histories, widely used, which, in the supposed interest of the Church, misrepresent in the grossest manner all these transactions in which Galileo was concerned. *Sancta simplicitas!* The Church has no worse enemies than those who devise and teach these perversions. They are simply rooting out, in the long run, from the minds of the more thoughtful scholars, respect for the great organization which such writings are supposed to serve. Their work is just as futile as that of writers of school histories which in the supposed Protestant interest misrepresent the Roman doctrine of indulgences.*

The Protestant Church was hardly less energetic against the new astronomy than the mother Church had been. The sacred science of the first Lutheran Reformers was transmitted as a precious legacy, and in the next century was made much of by Calovius. His great learning and determined orthodoxy gave him leadership in the Lutheran Church. Utterly refusing to look at ascertained facts, he cited the turning back of the shadow upon King Hezekiah's dial and the standing still of the sun for Joshua, denied the movement of the earth, and denounced the Copernican view as clearly opposed to Scripture. To this day his arguments are repeated by sundry orthodox leaders of American Lutheranism.

As to the other branch of the reformed Church, Turretin, Calvin's famous successor, even after Kepler and Newton had established the theory of Copernicus and Galileo, put forth his compendium of theology, in which he proved from a multitude of scriptural texts that the heavens, sun, and moon move about the earth, which stands still in the center.† In England we see similar theological efforts even after they had become utterly futile: among the strict churchmen, the great Dr. South denounced the Royal Society as "irreligious," and among the Puritans the eminent John Owen declared that Newton's discoveries were "built on fallible phenomena and advanced by many arbitrary presump-

* For the persecutions of Galileo's memory after his death, see Gebler, Wohlwill, but especially Th. Martin, p. 243, and elsewhere. For the persecution of Galileo's memory, see Th. Martin, chapters ix and x. For documentary proofs, see L'Epinois. For a collection of the slanderous theories invented against Galileo, see Martin, final chapters and appendix. Both these authors are devoted to the Church, but, unlike Monsignor Marini, are too upright to resort to the pious fraud of suppressing documents or interpolating pretended facts.

† For Calovius, see Zoeckler, Geschichte, vol. i, pp. 684 and 763. For Calvin and Turretin, see Shields, The Final Philosophy, pp. 60, 61.

tions against evident testimonies of Scripture." Even Milton seems to have hesitated between the two systems. At the beginning of the eighth book of Paradise Lost he makes Adam state the difficulties of the Ptolemaic system, and then brings forward an angel to make the usual orthodox answers: later, Milton seems to lean toward the Copernican theory, for, referring to the earth, he says:

> "Or she from west her silent course advance
> With inoffensive pace, that spinning sleeps
> On her soft axle, while she faces even
> And bears thee soft with the smooth air along."

Yet English orthodoxy continued to assert itself. In 1724 John Hutchinson, professor at Cambridge, published his *Moses' Principia*, a system of philosophy in which he sought to build up a complete physical system of the universe from the Bible. In this he assaulted the Newtonian theory as "atheistic," and led the way for similar attacks by such Church teachers as Horne, Duncan Forbes, and Jones of Nayland. But one far greater than these involved himself in this view. That same limitation of his reason by the simple statements of Scripture which led John Wesley to declare that "unless witchcraft is true, nothing in the Bible is true," led him, while giving up the Ptolemaic theory and accepting in a general way the Copernican, to suspect the demonstrations of Newton. Happily, his inborn nobility of character lifted him above any bitterness or persecuting spirit, or any imposition of doctrinal tests which could prevent those who came after him from finding their way to the truth.

But in the midst of this vast expanse of theologic error signs of right reason began to appear, both in England and America. Noteworthy is it that Cotton Mather, bitter as was his orthodoxy regarding witchcraft, accepted, in 1721, the modern astronomy fully, with all its consequences.

In the following year came an even more striking evidence that the new scientific ideas were making their way in England. In 1722 Thomas Burnet published the sixth edition of his "Sacred Theory of the Earth." In this he argues as usual to establish the scriptural doctrine of the earth's stability; but in his preface he sounds a remarkable warning. He mentions the great mistake into which St. Augustine led the Church regarding the doctrine of the antipodes, and says, "If within a few years or in the next generation it should prove as certain and demonstrable that the earth is moved, as it is now that there are antipodes, those that have been zealous against it, and engaged the Scripture in the controversy, would have the same reason to repent of their forwardness that St. Augustine would now, if he were still alive."

Fortunately, too, Protestantism had no such power to oppose

the development of the Copernican ideas as the older Church had enjoyed. Yet there were some things in its warfare against science even more indefensible. In 1772 the famous English expedition for scientific discovery sailed from England under Captain Cook. Greatest by far of all the scientific authorities chosen to accompany it was Dr. Priestley. Sir Joseph Banks had especially invited him. But the clergy of Oxford and Cambridge interfered. Priestley was considered unsound in his views of the Trinity; it was evidently suspected that this might vitiate his astronomical observations; he was rejected, and the expedition crippled.

The orthodox view of astronomy lingered on in other branches of the Protestant Church. In Germany even Leibnitz attacked the Newtonian theory of gravitation on theological grounds, though he found some little consolation in thinking that it might be used to support the Lutheran doctrine of consubstantiation.

In Holland the Calvinistic Church was at first strenuous against the whole new system, but we possess a comical proof that Calvinism even in its strongholds was powerless against it. For in 1642 Blaer published at Amsterdam his book on the use of globes, and, in order to be on the safe side, devoted one part of his work to the Ptolemaic and the other to the Copernican scheme, leaving the benevolent reader to take his choice.*

Nor have efforts to renew the battle in the Protestant Church been wanting in these latter days. The attempt in the Church of England in 1864 to fetter science, which was brought to ridicule by Herschel, Bowring, and De Morgan; the assemblage of Lutheran clergy at Berlin in 1868 to protest against "science falsely so called," are examples of these. Fortunately, to the latter came Pastor Knak, and his denunciations of the Copernican theory as absolutely incompatible with a belief in the Bible, dissolved the whole assemblage in ridicule.

In its recent dealings with modern astronomy the wisdom of the Catholic Church in the more civilized countries has prevented its yielding to some astounding errors into which one part of the Protestant Church has tumbled heedlessly.

Though sundry leaders in the older Church have committed

* For the attitude of Leibnitz, Hutchinson, and the others named toward the Newtonian theory, see Lecky, History of England in the Eighteenth Century, chap. ix. For John Wesley, see also his Compendium of Natural Philosophy, being a Survey of the Wisdom of God in the Creation, London, 1784. See also Leslie Stephen, Eighteenth Century, vol. ii, p. 413. For Owen, see his works, vol. xix, p. 310. For Milton, see place cited. For Cotton Mather's view, see The Christian Philosopher, London, 1721, especially pp. 16 and 17. For the case of Priestley, see Weld, History of the Royal Society, vol. ii, p. 56, for the facts and the admirable letter of Priestley upon this rejection. For Humboldt, see his Life, by Bruhns and Lassell, London, 1873, vol. ii, p. 411. For Blaer's book, see his L'Usage des Globes, Amsterdam, 1642.

the absurd error of allowing a text-book and sundry review articles to appear which grossly misstate the Galileo episode, with the certainty of ultimately undermining confidence in her teachings among her more thoughtful young men, she has kept clear of the folly of continuing to tie her teachings, and the acceptance of our sacred books, to an adoption of the Ptolemaic theory.

Not so with American Lutheranism. In 1873 was published in St. Louis, at the publishing house of the Lutheran Synod of Missouri, a work entitled *Astronomische Unterredung*, the author being well known to be a late president of a Lutheran Teachers' Seminary.

No attack on the whole modern system of astronomy could be more bitter. On the first page of the introduction the author, after stating the two theories, asks, "Which is right?" and says: "It would be very simple to me which is right, if it were only a question of human import. But the wise and truthful God has expressed Himself on this matter in the Bible. The entire Holy Scripture settles the question that the earth is the principal body (*Hauptkörper*) of the universe, that it stands fixed, and that sun and moon only serve to light it."

The author then goes on to show from Scripture the folly not only of Copernicus and Newton, but of a long line of great astronomers in more recent times. He declares: "Let no one understand me as inquiring first where truth is to be found—in the Bible or with the astronomers. No, I know that beforehand—that my God never lies; never makes a mistake; out of His mouth comes only truth, when He speaks of the structure of the universe, of the earth, sun, moon, and stars. . . .

"Because the truth of the Holy Scripture is involved in this, therefore the above question is of the highest importance to me. . . . Scientists and others lean upon the miserable reed (*Rohrstab*) that God teaches only the order of salvation, but not the order of the universe."

Very noteworthy is the fact that this late survival of an ancient belief based upon text-worship is found not in the teachings of any zealous priest of the mother Church, but in those of an eminent professor in that branch of Protestantism which claims special enlightenment.*

Nor has the warfare against the dead champions of science been carried on by the older Church alone.

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* For the amusing details of the attempt in the English Church to repress science, and of the way in which it was met, see De Morgan, Paradoxes, p. 42. For Pastor Knak and his associates, see the Revue des Deux Mondes, 1868. For the recent Lutheran works against the Copernican astronomy, see among others Astronomische Unterredung zwischen einem Liebhaber der Astronomie und mehreren berühmten Astronomer der Neuzeit. J. C. W. L. St. Louis, 1873.

On the 10th of May, 1859, Alexander von Humboldt was buried. His labors had been among the glories of the century, and his funeral was one of the most imposing that Berlin had ever seen: among those who honored themselves by their presence was the prince regent, afterward the Emperor William I; but of the clergy it was observed that none were present save the officiating clergyman and a few regarded as unorthodox.*

We return now to the sequel of the Galileo case.

Having gained their victory over Galileo, living and dead, having used it to scare into submission the professors of astronomy throughout Europe, conscientious churchmen exulted. Loud was their rejoicing that the "heresy," the "infidelity," the "atheism" involved in believing that the earth revolves about its axis and moves around the sun had been crushed by the great tribunal of the Church, acting in strict obedience to the expressed will of one Pope and the written order of another. As we have seen, all books teaching this hated belief were put upon the Index of books forbidden to Christians, and that Index was prefaced by a bull enforcing this condemnation upon the consciences of the faithful throughout the world, and signed by the reigning Pope.

The losses to the world during this complete triumph of theology were even more serious than at first appears: one must especially be mentioned. There was then in Europe one of the greatest thinkers ever given to mankind—René Descartes.† Mistaken though many of his theories were, they bore a rich fruitage of truth. The scientific warriors had stirred new life in him, and he was working over and summing up in his mighty mind all the researches of his time. The result would have made an epoch in history. His aim was to combine all knowledge and thought into a Treatise on the World, and in view of this he gave eleven years to the study of anatomy alone. But the fate of Galileo robbed him of all hope, of all courage; the battle seemed lost; he gave up his great plan forever.

But ere long it was seen that the triumph was really a prodigious defeat. From all sides came proofs that Copernicus and Galileo were right; and although Pope Urban and the Inquisition held Galileo in strict seclusion, forbidding him even to *speak* regarding the double motion of the earth; and although this condemnation of "all books which affirm the motion of the earth"

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* See Bruhns and Lassell, Life of Humboldt, London, 1873, vol. ii, p. 411.

† For Descartes's discouragement, see Humboldt, Cosmos, London, 1851, vol. iii, p. 21; also, Lange, Geschichte des Materialismus, vol. i, p. 222, where the letters of Descartes are given, showing his despair, and the relinquishment of his best thoughts and works in order to preserve peace with the Church; also, Saisset, Descartes et ses Précurseurs, pp. 100 *et seq.*; also, Jolly, Histoire du Mouvement intellectuel au XVI^e^ Siècle, vol. i, p. 390.

was kept on the Index; and although the papal bull still bound the "Index" and the condemnations in it on the consciences of the faithful; and although colleges and universities under Church control were compelled to teach the old doctrine;—it was seen by clear-sighted men everywhere that this victory of the Church was a disaster to the victors.

New champions pressed on. Campanella, full of vagaries as he was, wrote his Apology for Galileo, though for that and other heresies, religious and political, he seven times underwent torture.

And Kepler comes: he leads science on to greater victories. Copernicus, great as he was, could not disentangle scientific reasoning entirely from the theological bias. The doctrines of Aristotle and Thomas Aquinas as to the necessary superiority of the circle had vitiated the minor features of his system, and left breaches in it through which the enemy was not slow to enter; but Kepler sees these errors, and by wonderful genius and vigor he gives to the world the three laws which bear his name, and this fortress of science is complete. He thinks and speaks as one inspired. His battle is severe. He is solemnly warned by the Protestant Consistory of Stuttgart "not to throw Christ's kingdom into confusion with his silly fancies," and as solemnly ordered to "bring his theory of the world into harmony with Scripture": he is sometimes abused, sometimes ridiculed, sometimes imprisoned. Protestants in Styria and Würtemberg, Catholics in Austria and Bohemia press upon him; but Newton, Halley, Bradley, and other great astronomers follow, and to science remains the victory.*

Yet this did not end the war. During the seventeenth century, in all France, after all the splendid proofs added by Kepler, no one dared openly teach the Copernican theory, and Cassini, the great astronomer, never declared it. In 1672 the Jesuit, Father Riccioli, declared that there were precisely forty-nine arguments for the Copernican theory and seventy-seven against it. Toward the end of the seventeenth century, after the demonstrations of Sir Isaac Newton, even Bossuet, the great Bishop of

* For Campanella, see Amabile, Fra Tommaso Campanella, Napoli, 1882, especially vol. iii; also, Libri, vol. iv, pp. 149 *et seq.* Fromundus, speaking of Kepler's explanation, says, "Vix teneo ebullientem risum." This is almost equal to the New York Church Journal, speaking of John Stuart Mill as "that small sciolist," and of the preface to Dr. Draper's great work as "chippering." How a journal, generally so fair in its treatment of such subjects, can condescend to such weapons, is one of the wonders of modern journalism. For the persecution of Kepler, see vol. i, p. 392; also Heller, Geschichte der Physik, vol. i, pp. 281 *et seq.*; also Reuschle, Kepler und die Astronomie, Frankfurt a. M., 1871, pp. 87 *et seq.*; also Professor Sigwart, Kleine Schriften pp. 211 *et seq.* There is poetic justice in the fact that these two last-named books come from Würtemberg professors. See also the New Englander for March, 1884, p. 178.

Meaux, the foremost theologian that France has ever produced, declared it contrary to Scripture.

Nor did matters seem to improve rapidly in the following century. In England, John Hutchinson, as we have seen, published in 1724 his *Moses' Principia* maintaining that the Hebrew Scriptures are a perfect system of natural philosophy, and are opposed to the Newtonian system of gravitation; and, as we have also seen, he was followed by a long list of noted men in the Church. In France, two eminent mathematicians published in 1748 an edition of Newton's Principia; but, in order to avert the censure of the Church, they felt obliged to prefix to it a statement absolutely false. Three years later, Boscovich, the great mathematician of the Jesuits, used these words: "As for me, full of respect for the Holy Scriptures and the decree of the Holy Inquisition, I regard the earth as immovable; nevertheless, for simplicity in explanation I will argue as if the earth moves; for it is proved that of the two hypotheses the appearances favor that idea."

In Germany, especially in the Protestant part of it, the war was even more bitter, and it lasted through the first half of the eighteenth century. Eminent Lutheran doctors of divinity flooded the country with treatises to prove that the Copernican theory could not be reconciled with Scripture.

In the theological seminaries and in many of the universities where clerical influence was strong they seemed to sweep all before them; and yet at the middle of the century we find some of the clearest-headed of them aware of the fact that their cause was lost.*

In 1757 the most enlightened perhaps in the whole line of the popes, Benedict XIV, took up the matter, and the Congregation of the Index secretly allowed the ideas of Copernicus to be tolerated. Yet in 1765 Lalande, the great French astronomer, tried in vain at Rome to induce the authorities to remove Galileo's works from the Index. Even at a date far within our own nineteenth century the authorities of many universities in Catholic Europe, and especially those in Spain, excluded the Newtonian system: in 1771 the greatest of them all, the University of Salamanca, being urged to teach physical science, refused, making

* For Cassini's position, see Henri Martin, Histoire de France, vol. xiii, p. 175. For Riccioli, see Daunou, Études Historiques, vol. ii, p. 439. For Bossuet, see Bertrand, p. 41. For Hutchinson, see Lyell, Principles of Geology, p. 48. For Wesley, see his work, already cited. As to Boscovich, his declaration, mentioned in the text, was in 1746, but in 1785 he seemed to feel his position in view of history, and apologized abjectly: Bertrand, pp. 60, 61. See also Whewell's notice of Le Sueur and Jacquier's introduction to their edition of Newton's Principia. For the struggle in Germany, see Zoeckler, Geschichte der Beziehungen zwischen Theologie und Naturwissenschaft, vol. ii, pp. 45 *et seq.*

answer as follows: "Newton teaches nothing that would make a good logician or metaphysician; and Gassendi and Descartes do not agree so well with revealed truth as Aristotle does."

Vengeance upon the dead also has continued far into our own century. On the 5th of May, 1829, a great multitude assembled at Warsaw to honor the memory of Copernicus and to unveil Thorwaldsen's statue of him.

Copernicus had lived a pious, Christian life; he had been beloved for unostentatious Christian charity; with his religious belief no fault had ever been found; he was a canon of the Church at Frauenberg, and over his grave had been written the most touching of Christian epitaphs. Naturally, then, the people expected a religious service; all was understood to be arranged for it; the procession marched to the church and waited. The hour passed, and no priest appeared; none could be induced to appear. Copernicus, gentle, charitable, pious, one of the noblest gifts of God to religion as well as to science, was evidently still under the ban. Five years after that, his book was still standing on the Index of books prohibited to Christians.

The edition of the Index published in 1819 was as inexorable toward the works of Copernicus and Galileo as its predecessors had been; but in the year 1820 came a crisis. Canon Settele, Professor of Astronomy at Rome, had written an elementary book in which the Copernican system was taken for granted. The Master of the Sacred Palace, Anfossi, as censor of the press, refused to allow the book to be printed unless Settele revised his work and treated the Copernican theory as merely a hypothesis. On this Settele appealed to Pope Pius VII, and the Pope referred the matter to the Congregation of the Holy Office. At last, on the 16th of August, 1820, it was decided that Settele might teach the Copernican system as established, and this decision was approved by the Pope. This aroused considerable discussion, but finally, on the 11th of September, 1822, the cardinals of the Holy Inquisition graciously agreed that "the printing and publication of works treating of the motion of the earth and the stability of the sun, in accordance with the general opinion of modern astronomers, is permitted at Rome." This decree was ratified by Pius VII, but it was not until thirteen years later, in 1835, that the condemnation of works defending the double motion of the earth was left out of the Index.

This was not a moment too soon, for, as if the previous proofs had not been sufficient, each of the motions of the earth was now absolutely demonstrated anew, so as to be recognized by the ordinary observer. The parallax of fixed stars, shown by Bessel as well as other noted astronomers in 1838, clinched forever the doctrine of the revolution of the earth around the sun, and in

1851 the great experiment of Foucault with the pendulum showed to the human eye the earth in motion around its own axis. To make the matter complete, this experiment was publicly made in one of the churches at Rome by the eminent astronomer, Father Secchi, of the Jesuits, in 1852—just two hundred and twenty years after the Jesuits had secured Galileo's condemnation.*

INVOLUNTARY MOVEMENTS.

By JOSEPH JASTROW, Ph. D.,
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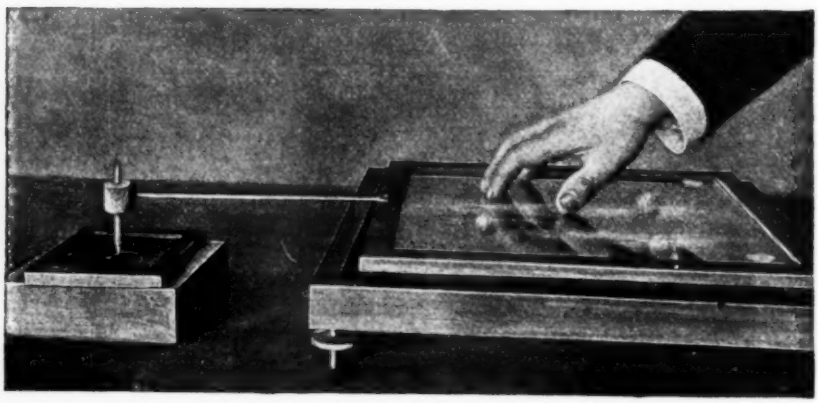
QUITE a number of delusions find a common point of origin in the wide-spread belief that our thoughts and actions are to be completely explained by reference to what our consciousness tells us and what our will directs. The equally important realm of the unconscious and the involuntary is too apt to be overlooked. It is true that we are ready to admit that, in some unusual and semi-morbid conditions, persons will show these untoward phenomena; but we are slow to believe that they have any bearing upon the soundly reasoned and skillfully directed actions of our own intelligence. Accordingly, when from time to time there comes to the front some phenomenon diverging from the ordinary experience of mankind and apparently revealing obscure laws, we fly to some unproved and extreme explanation, and fail to recognize in our daily unconscious and involuntary activity the true source of the apparent mystery. While it is very reasonable to trust the verdict of our consciousness, yet it is equally

* For good statements of the final action of the Church in the matter, see Gebler; also Zoeckler, Geschichte der Beziehungen, etc., ii, 352. See also Bertrand, Fondateurs de l'Astronomie moderne, p. 61; Flammarion, Vie de Copernic, chap. ix. As to the time when the decree of condemnation was repealed, there have been various pious attempts to make it earlier than the reality. Artaud, p. 307, cited in an apologetic article in the Dublin Review, September, 1865, says that Galileo's famous dialogue was published in 1744, at Padua, entire, and with the usual approbations. The same article also declares that in 1818 the ecclesiastical decrees were repealed by Pius VII in full Consistory. Whewell accepts this; but Cantu, an authority favorable to the Church, acknowledges that Copernicus's work remained on the Index as late as 1835 (Cantu, Histoire universelle, vol. xv, p. 483); and with this Th. Martin, not less favorable to the Church, but exceedingly careful as to the facts, agrees; and the most eminent authority of all, Prof. Reusch, of Bonn, in his Index der verbotenen Bücher, Bonn, 1885, vol. ii, p. 396, confirms the above statement in the text exactly as I made it in 1871. For a clear statement of Bradley's exquisite demonstration of the Copernican theory by reasonings upon the rapidity of light, etc., and Foucault's exhibition of the rotation of the earth by the pendulum experiment, see Hoefer, Histoire de l'Astronomie, pp. 492 *et seq.* For more recent proofs of the Copernican theory, by the discoveries of Bunsen, Bischoff, Benzenburg, and others, see Jevons, Principles of Science.

desirable that this confidence should be accompanied by an understanding of the conditions under which the evidence is presumably valid and when likely to mislead. Sense deceptions, faulty observation, exaggeration, neglect, fallacy, illusion, and error abound on all sides and emphasize the need of a calm judgment, a well-equipped intellect, a freedom from haste and prejudice, an appreciation of details and nice distinctions, in the determination of truth and the maintenance of mental health.

For these and other reasons it is important to demonstrate experimentally the readiness with which normal individuals may be made to yield evidence of unconscious and involuntary processes. When, some years ago, the American public was confronted with the striking phenomena of muscle-reading, the wildest speculations were indulged in regarding its true *modus operandi;* and the suggestion that it was due to unconscious indications skillfully interpreted was ridiculed, mainly for the reasons that this explanation was hardly applicable to certain extreme instances involving considerable good fortune, other and subtler modes of interpretation, as well as some exaggeration in the accounts, and that so many worthy and learned persons were absolutely certain that they had given no indications whatever. For a time the view that mind-reading was muscle-reading rested upon rather indirect evidence, and upon modes of reasoning that do not



THE AUTOMATOGRAPH.—When in use a screen is interposed concealing the apparatus from the subject. There is also a sheet of paper on the upper glass plate, which has been removed to show the glass balls.

carry great conviction to the ordinary mind. To supplement this evidence by a clear exposition of the naturalness and regularity of these involuntary movements is our present task.

Inasmuch as the movements in question are often very slight, delicate apparatus is necessary, the description of which may properly precede an account of the results. There is first a strong

wooden frame, holding a heavy plate glass, fifteen inches square, and mounted on three brass legs, with screw adjustments by means of which the plate may be brought into exact level. Upon the plate glass are placed in the form of a triangle three very perfectly turned and polished brass balls, and upon the balls rests a thin crystal plate glass fourteen inches square, set in a light wooden frame. Covering the upper glass is a sheet of paper, and upon the paper the subject lightly rests the finger-tips of one hand. When all is properly adjusted, and glass and balls are rubbed smooth with oil, it is quite impossible to hold the apparatus still for more than a few seconds; the slightest unsteadiness or movement of the hand at once sets the apparatus going. If one closes his eyes and thinks intently of something, one readily forms the conviction that the glass remains quiet, but a bystander is equally convinced of the opposite. The rest of the apparatus is designed to give a permanent record of these movements. Fastened to the light frame containing the upper glass is a slender rod some ten inches long, bearing at its end a cork, and piercing the cork is a small glass tube that serves to hold a snugly fitting glass rod. The rod is drawn to a smooth rounded point, and when in position rests upon a piece of glazed paper that has been blackened over an oil-flame, and is smoothly stretched over a small glass plate. The point of the rod thus records easily and accurately every movement of the hand that is imparted to the upper plate, and by the manner of its adjustment accommodates itself to all irregularities of movement or surface. Inasmuch as the main purpose of the apparatus is to write involuntary movements, it may not be amiss to name it the "automatograph," and speak of the record it yields as an "automatogram."*

FIG. 1.— ⇒ READING COLORS. Time of record, 95 seconds.

In all the figures A represents the beginning of the record, Z the end. In Figs. 4 and 6 the numbers 1, 2, 3, 4 indicate the points of the record 15, 30, 45, 600 seconds—in Fig. 11, 30, 60, 90, 120 seconds—after the start. *The arrow indicates the direction in which the object attended to was situated.* The tracings are permanently fixed by bathing them in a weak solution of shellac and alcohol.

Various means may be employed to hold the attention of the subject in a definite direction, and in all he is instructed to think as little as possible of his hand, making an effort, if he chooses, to

* The apparatus was designed and the results were obtained in the Psychological Laboratory of the University of Wisconsin. The success of the investigation and the labor of obtaining the results are to a great extent due to the skill and industry of Miss Helen West, A. B., 1891, of the University of Wisconsin.

keep it from moving. A large screen is interposed between the subject and the record to prevent him from indirectly seeing what is going on. On the wall facing him, some eight feet distant, are some small patches of color, the names of which he is asked to call out. The colors are small enough to necessitate close attention in their distinction, and the record of the hand, after the subject has been employed in this way for a minute or two, is usually quite significant. An average result is presented in Fig. 1. The hand moves clearly and directly toward the wall where the colors hang; the movement is at times halting and uncertain, but its general trend is unmistakable. Moreover, the result can not in general be anticipated, not alone because there are marked differences between individuals in the readiness with which they will manifest involuntary movements, but also because the intensity of the attention and the momentary condition of the subject are important and variable factors in the result. With very good subjects it becomes quite safe to predict the general nature of the result, and the different tracings of the same subject bear a family resemblance to one another.

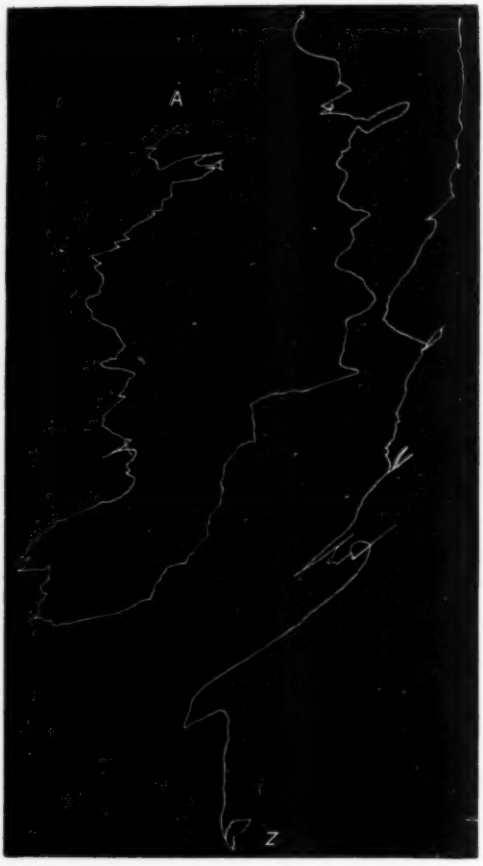


FIG. 2.—READING COLORS ARRANGED IN THREE ROWS. Shows movement of the hand parallel with movement of the attention. Time of record, 90 seconds. The first line was read in this direction ↓, the second in this ↑, the third in this ↓. At the turn from the second to the third line the record is interrupted.

A more unusual but very striking form of involuntary movement is shown in Fig. 2. As before, the subject's attention was fixed upon the colors on the wall, but these were arranged in three rows, the first being read from left to right, the second from right to left, and the third from left to right again. The record plainly indicates where the change of direction of reading took place; the correspondence between the movements of the hand and of the

attention is perfect, while the movements are unusually direct and extensive. The originator of this record is the best of our subjects, in the sense that the involuntary movements are largest and most predictable.

We may substitute reading from a printed page for the naming of colors and obtain a very similar result. An example is given in Fig. 3, showing, as before, the movement of the hand toward the object of attention.

FIG. 3.— ⇔ READING PRINTED PAGE. Time of record, 45 seconds.

The attention may be directed to a sound as well as to a visual impression; this may be conveniently done by listening to the strokes of a metronome. In order to further strengthen the attention the subject is required to count the strokes, the usual rate being one hundred and forty per minute.

FIG. 4.— ⇔ COUNTING THE STROKES OF A METRONOME. Time of record, 70 seconds. It also illustrates slight hesitation before the movement toward the metronome begins.

The result—a typical illustration is given in Fig. 4—shows that the hand moves toward the metronome. If the metronome be placed in front of the subject in one experiment and behind him in the next, an interesting contrast may be observed. The effect of close attention to the regular strokes of a metronome may show itself in another way. We all appreciate how strong is the tendency to beat time to enlivening music, by tapping with the hands, or stamping with the feet, or nodding with the head; and Dr. Lombard has shown that music is capable of effecting such thoroughly involuntary movements as a sudden rise of the leg when the patella of the knee is struck. It is not surprising, therefore, to find evidences of periodic movements in these automatograms, and in some instances, such

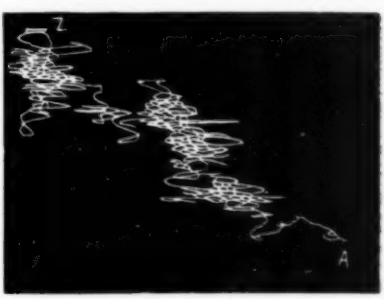


FIG. 5.—COUNTING THE STROKES OF A METRONOME. Shows the oscillation of the movements with the strokes of the metronome.

as Fig. 5, this pervades the whole record. Here the hand moves to and fro, keeping time—not accurately at all, but in a general way—with the strokes of the metronome.

FIG. 6.— ⇔ COUNTING THE OSCILLATIONS OF A PENDULUM. Time of record, 45 seconds.

To obtain similar results for a visual impression, a silently swinging pendulum is used, the subject watching the oscillations and counting them. The result is more frequently a movement toward the pendulum, Fig. 6, but occasionally there appear periodic movements due to the pendulum. A very excellent instance of the latter appears in Fig. 7.

FIG. 7.— ⇔ COUNTING PENDULUM OSCILLATIONS. Time of record, 80 seconds. Shows movement toward the pendulum at first, and then movements synchronous with its oscillations.

We may more closely approximate the ordinary experiment of the muscle-reader by giving the subject some object to hide, say a knife, and then asking him to place his hand upon the automatograph and think intently of the place of concealment. As before, there is a movement of the hand, and on the basis of the general direction of this movement one may venture a prediction of the direction in which the knife lies. The results will show all grades of success, from complete failure to an accurate localizing of the object, but as good a record as Fig. 8 is not infrequent. In this case the eyes are closed, and we have not the aid of the senses

FIG. 8.— ⇔ THINKING OF A HIDDEN OBJECT. Time, 30 seconds.

in maintaining a concentrated attention; moreover, the position of the subject may not be suited to a ready movement in the direction of the hidden object.

A further interesting mode of concentrating the attention con-

sists in thinking of a building or locality in the neighborhood; a very good record obtained in this way appears in Fig. 9.

The peculiar line of Fig. 10 was obtained in an experiment in which a book was slowly carried about the room, the subject being required to continuously read from the page. It is evident that the hand followed the movement of the attention, not pre-

FIG. 9. — ← THINKING OF A LOCALITY. Time, 120 seconds. Also illustrates initial hesitancy followed by steady movement toward the object of thought.

cisely in a circle, but in an irregular outline, closing in upon itself. The great differences between individuals which the experience of the muscle-reader would lead us to expect are not lacking here. Some movements are direct and extensive, others circuitous and brief. Fig. 11 is a good type of a small movement, though it is quite constantly toward the object of the attention. This may be contrasted with another record in which there is a movement of six and a half inches in forty-five seconds. In some cases the first impulse carries the hand toward the object of thought, and is followed by considerable hesitation and uncertainty. A marked example of this tendency may be seen in Fig. 12. There is, too, an opposite type, in which the initial movements are variable, and the significant movement toward the object of thought comes later, when there is perhaps some fatigue. This tendency appears somewhat in Figs. 4 and 9.*

FIG. 10.— READING FROM PRINTED PAGE, the page being moved about the subject.

How far these movements are involuntary or unconscious must be largely determined by the subjective experiences of those who execute them. While here, as elsewhere, there is some difference

* A further point of importance for future research is the effect of the position of the subject upon the ease of the movement. A sufficient number of experiments were made to show that such an effect exists, and as a result a position was chosen allowing as nearly as possible of equally easy movements in all directions.

among individuals, the consensus of opinion indicates that the subject exercises no essential control over the results; and as a rule he is considerably surprised when the results are first shown to him. At times he becomes conscious of the loss of equilibrium of the apparatus, but the indication is rarely sufficiently definite to inform him of the direction of the movement. Not infrequently the movement is unconsciously performed, and is accompanied by a strong conviction that the apparatus has been stationary. In several cases an intentional simulation of the movements was produced for comparison with the other records; the difference between the two is considerable. An objective mode of determining the precise nature of the movements is certainly desirable, but the subjective experiences are entitled to weighty consideration.

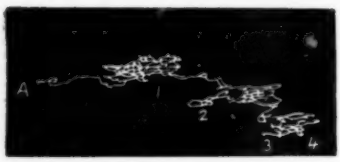


FIG. 11.— ⇒ COUNTING PENDULUM OSCILLATIONS. Time, 120 seconds. Illustrates slow and indirect movement.

No elaborate comment upon the significance of these results is necessary. They merely outline the initial steps in the study of involuntary movements, and leave much to be done to complete our knowledge of the details and variations of this interesting but

FIG. 12.— ⇒ COUNTING STROKES OF METRONOME. Time of record, 90 seconds. Illustrates initial directness of movement followed by hesitancy.

subtle phenomenon. The results go sufficiently far, perhaps, to indicate how readily one may obtain permanent records of involuntary movements, and how closely related these are to the processes upon which the success of the muscle-reader depends. They bear a striking corroboration of the view that all thought is only more or less successfully repressed action, and that, as an eminent muscle-reader puts it, all willing is either pushing or pulling.

THE skin of the giraffe, according to M. H. Bryden, is remarkably thick, reaching in some parts three centimetres. A complete specimen, for mounting, is worth from thirteen to twenty-three dollars. The author asserts that the animal easily escapes detection in its natural condition by the resemblance of its long neck to the trunk of a tree.

SCIENCE AND FINE ART.*

By EMIL DU BOIS-REYMOND.

I.

WHEN we represent to ourselves the mental stature of the extraordinary man in whose honor we meet every year on this day, we are ever anew astonished at the boundless breadth of his view and the almost endless diversity of the subjects in which he was interested. It appears hardly comprehensible that the state paper which adjudged the principality of Neufchâtel to the King of Prussia came from the same pen as the Protogea, the Analysis of the Infinite, and the true measure of force from the same head as the pre-established harmony and the Theodicy. Yet on closer examination a gap is revealed in this picture which at first sight appeared all-inclusive. Aside from the Latin poem in which Leibnitz extravagantly glorifies Brand's discovery of phosphorus, we seek in vain for any relation of our hero to art. That his *Ars combinatoria* had nothing to do with fine art does not need to be said. Only occasionally and rarely do we meet in his writings and letters remarks on art and the beautiful. Once he permits himself to be heard at length on the pleasure we receive from music, the causes of which he seeks in a uniform though invisible order in the movements of the trembling strings "which . . . produces in us . . . a harmonious resonance, by which our vital spirits are also moved."† But the world of feeling was only dimly visible to Leibnitz. He saw the Alps and the Italian art treasures with his eyes, but was, as we now say, soul-blind. The same lack of appreciation of fine art is seen in Voltaire, who was comparable for his various learning with Leibnitz; and we have to come down to a third generation, to Diderot in France, and Winckelmann and Lessing in Germany, to find decisive interest in fine art and appreciation of its position in the culture-life of the people.

The period thus defined was, aside from a few phenomenal examples, one of decline in art, while it was one of the most famous in science. When we regard the historical development of these two lines of human activity, we find no conformity in their courses. During the highest bloom of Grecian plastic art there was hardly any science. At the beginning of the art period which we are accustomed to call the *cinque-cento* stands out the giant figure of

* Address on Leibnitz Commemoration-day in the Academy of Sciences at Berlin, July 3, 1890.

† Die philosophischen Schriften von G. W. Leibnitz. Published by C. J. Gerhardt. Vol. ii, p. 87. Berlin, 1890.

Leonardo da Vinci, who, in addition to his immortal art-creations, was a physicist of high rank, yet he was as such so far ahead of his time that the example can not be cited as evidence that the rise of science conditions also the rise of art. Michael Angelo died on the same day that Galileo was born. In the common eminence of art and science at the beginning of this century we see only a coincidence. Art has since then continued at best at the same height, while science is still careering on its course of irrepressible victory.

The two lines are in fact so different that it is easily to be seen that science can help art and art science only externally. "Nature," said Goethe, addressing Eckermann, without perceiving how sharply his words might be applied to a side of his own scientific efforts—"Nature knows no pastime; she is always true, always earnest, always severe; she is always right, and faults and mistakes are always man's."* In order adequately to perceive the correctness of this expression, one must be accustomed, when he applies his own hand to work as an experimenter or observer, to look into the inexorable face of Nature, and, we might almost say, to take upon himself the immense responsibility that is involved in the determination of even the most insignificant fact. What happens at this moment, under these circumstances, will also happen, under the same circumstances, for a negatively endless time, and will likewise happen after a positively endless time; this is the pregnant significance of every rightly interpreted experiment. Only the mathematician, whose work is more nearly allied to that of the experimental investigator than we are used to conceive, can oppose eternally inviolable laws to the same feeling of responsibility. Sworn witnesses before the tribunal of reality, they both strive after knowledge of the world as it is, within the limits imposed upon us by the nature of our intellect. For this painful pressure under which he labors, the investigator is compensated by the knowledge that even the least of his achievements is a step forward above the highest stage reached by his greatest predecessors; that it may contain the germ of immensely important theoretical knowledge and practical achievements, as Wollaston's lines in the spectrum contained the germ of spectrum analysis; that such a prize invites not only the genius raised up by Nature, but also the conscientious industry of the moderately gifted; and that science, bestowing upon the human mind the mastery of Nature, is the ruling organ of civilization; that without it there never has been a true civilization; and that without it civilization, together with art and its works, might any day sink again hopelessly, as they did on the extinction of the ancient world.

* Gespräche mit Goethe, etc. Leipsic, 1836, vol. ii, p. 68 (1829).

The investigator can also be comforted with the knowledge that a thoughtless multitude enjoying the benefits conferred upon it by him, hardly knows to whom it owes them; that while the name of every musical *virtuoso* is in all mouths, and is certain of immortality in the Conversations-Lexicons of the fashionable classes, the name is substantially unknown among us of him who achieved that supreme triumph of inventive genius of making perceptible, through a copper wire stretched over wide regions and over mountain and valley, the sound of a voice as though it was speaking into our ears. "Knowledge is earnest, art is happy," we might paraphrase the poet's expression, without lessening its applicability. Art is the empire of the beautiful; of the creation of that which inspires in us a semi-sensational, semi-spiritual pleasure; and saying this we also say that it is in its widest scope an empire of freedom. In it rule no stiff laws; no strict causality binds the events of the present to those of the past and of the future; no standard unconditionally warrants success. The changing taste of times, peoples, and men assumes to praise and blame, as when the magnificence of Gothic church architecture became the sport of the eighteenth century. Here the definition of genius as the talent for patience goes to the ground; its happy inspiration produces a picture that seizes us and lifts us up with an elementary power which seems to mock the profound interpretation subsequently imposed upon it by art criticism; and the favored hand which perfects it is also a benefactor of care-laden manhood. It unfortunately lies in the nature of things that such force is not developed in every age. Here at one time the highest development is attained in some one direction, in trying to reach which again generation after generation despondently exhausts itself. The finest art theories can neither lift the individual over the limits of his natural ability, nor in the great whole prepare a better destiny for a declining art period. Of what profit is the discussion concerning idealism and realism which has divided the art world for a considerable time? Has it protected us against the hardly tolerable excesses of the latter? Seek for something new; the bold raising of a standard which the untaught multitude blindly follows, will bear the victory, till the antiquated is in some way supplemented by the fresh, or till a personality of commanding altitude unquestionably achieves the mastery.

Still less can pure science help art; and thus, intrinsically alien to one another, without either materially influencing the other, they go each its own way—the one steadily rising, sometimes more rapidly, sometimes more slowly, the other rising and falling in majestic waves. To desire to stamp one of the two, art alone, as the mark of the highest development of the power of the human mind, as not rarely occurs to persons unfamiliar with

science, is undoubtedly a mistake; but the human mind really shines the clearest when the luster of art is joined with the luster of science.

Furthermore, the same takes place here as in practical ethics. The lower the morals of an age or a people have sunk, the more talk there is about virtue. The more the native creative strength subsides and is dried up, the higher rises the flood of æsthetic theories. Hermann Lotze's History of Æsthetics in Germany * affords a wearisome and discouraging picture of this long and fruitless movement. The philosophers of all schools have outbid one another in framing abstract formulas for determining exactly what beauty is. It is unity in diversity, or fitness without purpose, or unconscious rationality, or the absolute in sensual existence, or the enjoyed harmony of the absolute spirit, and more of the same kind. But between these qualities ascribed to all beauty nominally constituting its essentials, and the perception of the beautiful, there is no more connection than there is between the ether and sonorous vibrations and the qualities made known to us by them. It would indeed be a vain undertaking to conceive an expression which shall equally cover the various kinds of beauty; the beauty of the Cosmos in contrast to chaos, of a mountain view, of a symphony, of a poetical work, of Ristori as Medea, of a rose; or in fine art alone, the beauty of the Cologne Cathedral, of the Hermes, of the Sistine Madonna, of a *genre* picture, of a landscape, of a picture of still life, or of a Japanese vine-weaving. We prefer to say that we in this as in many other points meet something in our organism that is inexplicable, something inexpressible, but something none the less certainly felt for all that, without which life would pass away grimly bare.

There is in Schiller's works a discussion concerning the beauty of the human body.† He distinguishes between an architectonic beauty and one that depends upon grace. Twenty years ago on Leibnitz's day, in an address on Leibnitz's ideas in later science, I attacked the rationalism in æsthetics in which the past century had been much entangled, and I ventured among other things the remark that "as little as for the effect of melody is an explanation conceivable of the charm which handsome forms of one sex have for the other." ‡ We can not in fact discern in close consideration, why this form which, according to Fechner, can be represented by a plain equation between three variables, should please us more than a thousand other possibilities. It can not be

* The seventh volume of Die Geschichte der Wissenschaften in Deutschland. Neuere Zeit. Munich, 1888.

† In the essay on Anmuth und Würde.

‡ Reden, etc., vol. i, Leipsic, 1886, pp. 49, 50.

derived from any abstract principle or architectonics or Hogarthian wave-line. A year after my remark, appeared Charles Darwin's Descent of Man, in which the doctrine of sexual selection, which was only indicated in the Origin of Species, was treated in detail and followed out to its consequences. But I have, too, a lively recollection of how Dove, when I was once contending with him against the validity of vitalism, embarrassed me with the objection that profusion prevails in organic nature, as, for example, in the feathers of a peacock, or of a bird-of-paradise, while Maupertuis's law of the least action excludes such waste in inorganic nature. The problem seems to be solved now, under the presumption that a kind of sense of beauty in their species exists among animals. The brightly colored wedding garment of the male bird may have originated in the females giving the preference to the most highly decorated suitor, under which an ever more richly adorned posterity is developed. The male birds-of-paradise may be seen at pairing-time emulously displaying their beauty before the female. The nightingale's gift of song may likewise be accounted for if, instead of pleasure in colored feathers, we ascribe musical perceptions to the females. Darwin carries his idea further, to the extent of assuming that certain sexual marks in the human race, the grave beard of the man and the luxuriant hair of the woman, may have been derived through sexual selection*. It is well known that the introduction of handsome Circassian slaves into the harems of prominent Turks has repeatedly changed the original Mongolian type into a figure of nobler pattern. Rising to a higher level, we can now find in the same idea the answer to the question, Where are the roots of the charm which female beauty exercises on man? According to our views, the woman was not made out of a rib of the first man, an assumption which encounters morphological difficulties, but it was the man himself who in the course of numerous generations made his woman by natural selection of such fashion as would please him, and, inversely, the woman her man. We now call this type beau-

* The Descent of Man and Selection in Relation to Sex. London, 1871, vol. ii, pp. 52, 89, 379, 400, 401. In his book on Darwinism, etc. (second London edition, 1889), Mr. Wallace rejected the explanation of the decorative plumage and the song of the male bird through selection by the female, and proposed other interpretations. But a writer recognized by Mr. Wallace himself as equally a student in this line, Mr. C. B. Poulton, in his work, The Colors of Animals, their Meaning and their Use (International Scientific Series), has sturdily taken up the defense of the Darwinian view against this attack, and exposed the untenability of Wallace's later explanation. Mr. Wallace has not failed to reply to this (Nature, No. 1082, vol. xlii, July 24, 1890); while Mr. R. J. Pocock, resting on Mr. G. W. Peckham's investigations, joins Mr. Poulton (ibid., No. 1086, August 1, 1890, p. 405). This is not the place to enter into the question, especially as my conclusion concerning the doctrine of sexual selection still holds, even if Mr. Wallace should be right on the single points of feather ornament and song.

tiful; but it is only necessary to cast a glance upon a Venus by Rubens or Titian, and to think of the many races of men, to recognize how little even this beauty is absolute.

An instance in which beauty seems to have allowed itself to be dismembered to the best advantage is afforded by the beauty that might be called mechanical. It is the least considered, because a peculiar training of the eye is required for its estimation. It is the beauty which a machine or a physical instrument can possess, of which every part has the right measure, the right form and position for its perfection. The definition, unconscious rationality, fits it well, for in this case the pleasure can with full right be traced back to the fact that we, by sufficient training, can unconsciously perceive how exactly that which was necessary has been done to connect firmness with lightness and as much mobility as is required, in order to obtain the most advantageous transference of force without useless expenditure of material. A driving-belt, it is true, looks neither beautiful nor unbeautiful; but since the strength of a connecting-rod needs to be greatest in the middle of its length, it pleases the educated vision to see it gradually swelling out from the ends to the middle. This kind of beauty is of course of most recent origin; and it should be remarked that it was, so far as I know, first perceived and raised to a principle in the making of our physical instruments in Germany by Georg von Reichenbach in Munich. At a time when instruments of perfect mechanical beauty were turned out of the shops of Munich and Berlin, there came to us from France and England only those on which stiff columns and fantastically ornamented cornices gave disagreeable reminders of the impure forms in the architecture and furniture of the Rococo.

I do not recollect what French mathematician in the last century endeavored to account for the impression of perfect satisfaction to the eye which the view of the cupola of St. Peter's in Rome produced. He measured the curves of the cupola, and found that their form was precisely that which under the given conditions afforded, by the rules of the higher statics, the maximum of stability. Thus, unconsciously, guided by a sure instinct, Michael Angelo solved in his model (the cupola was not built till after his death) a problem which was hardly comprehensible to his consciousness, and which had never, in his time, been mathematically discussed. The equation of beauty, if we may call it that, appears, moreover, in this case, to have had several roots; for there is at least one other form of cupola, of which that of the Val-de-Grâce in Paris occurs to me as a type, which makes quite as restful an impression, though perhaps not so elevating, as that of Michael Angelo's.

Mechanical beauty comes in here in the building art, and the

more frequently at this time because the iron constructions of the later period give more occasion than stone structures for its exhibition. The change of material has, according to Anton Hallmann's expression, produced a changed statics of feeling.* In the Eiffel Tower mechanical beauty is in conflict with plastic want of beauty, and in this reveals itself for the first time to many who would not otherwise have had occasion to perceive its effect. The new Forth Bridge is certainly not without it. Yet there is no question that even in stone buildings, besides many traditions and conventional tastes, the pleasure in definite forms, in the gentle swelling and tapering of Doric pillars upward, their expansion into the echinus and abacus, and in the profile of the architectural members, depends on mechanical beauty, as well as on the absence from the agreeable impression they make of the repulsive, which the senseless ornamentation of vulgar styles inflicts upon the refined taste.

Mechanical beauty plays a part even in the forms of organic nature, to the degree that much that is repulsive to the untutored eye delights the educated eye and fills it with admiration. That it is which the anatomist is pleased to discern in the structure of the bones, particularly of the joints; which on other grounds than its contradiction of the way the ancients painted death, makes a death-dance appear repulsive to him; which Benvenuto Cellini, to his credit, comprehended in a skeleton; and which, if only our understanding was adequate, every organized form would illustrate to us even in the aquarium and under the microscope. Even in the building up of the plant structure, Dr. Schwendener has demonstrated an economical adaptation of parts, characteristic of the organization, of which we can discern something in the sight of a broadly rooted oak pushing its massive head up toward air and light.

Mechanical beauty comes into consideration in the contemplation of animal forms, particularly of beasts of prey. A greyhound and a bull-dog, a thoroughbred race-horse and a brewer's draft-horse, a South Down and a merino sheep, an Algau Mountain steer and a Dutch milch-cow, are all handsome, though some among them, like the bull-dog and the Percheron horse, may appear ugly to a stranger; for in all of them the type of the species is modified for some adaptation.

Although science can not, as we have seen, inspire art in its departing life, nor communicate a new impulse to it, it can still afford it an inestimable service of another kind, by increasing its insight and improving its technical means, teaching it useful rules, and guarding it against errors. We are not thinking here

* Kunstbestrebungen der Gegenwart. Berlin, 1842, p. 71.

of a thing so primitive as the preparation of pigments or of certain knacks in casting; the less so because, as is well known, our colors are in a remarkable way poorer than those of an unscientific primitive time, and an unexcelled thinness of the metal is the mark of a genuine Greek bronze statue. It can hardly be necessary to recollect the long story of the benefits of this kind which scientific knowledge has conferred upon art. Linear perspective was discovered by the artists themselves, by Leonardo and Dürer. The laws of reflection and shadow-construction, which were still unknown to the ancient painters, if we may judge from the Pompeiian Narcissus-pictures, followed. In the representation of the rainbow, which had better be left unpainted, many and serious mistakes have been made, notwithstanding the teachings of optics. Statics furnished the sculptor important instruction concerning what is called ponderation. Aërial perspective owes its development, again, to the painters, particularly to those of northern lands.

The advance of science has added to those ancient helps much of importance, although it is not so fundamental, and many naturalists, among them some of the first rank, have interested themselves in making the new knowledge accessible to artists. The great masters of past centuries were guided by their feelings to the proper selection of colors, as, according to Johannes Müller, women of taste of all times are correct in the choice of their clothing;* and the Oriental carpet-weavers are not behind them. But the significance of such unconscious success could be perceived only after the subjective physiology of the sense of sight had been created by the older Darwin, Goethe, Purkinje, Johannes Müller, and others. These matters have been discussed by our fellow-member, Herr Ernst von Brücke, in his Physiology of Colors for industrial art, and his Fragments from the Theory of the Fine Arts,† with such special skill as only the rare combination of the artistic culture acquired in his father's studio with his own physiological knowledge could make possible. Chevreul pursued similar aims in France. Not less did Prof. von Helmholtz embody his profound knowledge of physiological optics in public lectures in the service of art, which owes to him likewise his fruitful conclusions concerning the nature of musical harmony. He explained among other things the relation in which differences of luster of real objects stand to those which the painter controls, and showed what means he could employ to overcome the difficulties growing out of them.‡ By imitation of the irradiation recognized by him in

* Handbuch der Physiologie des Menschen, etc. Vol. ii, Part II, Coblentz, 1838, p. 375.

† Physiologie der Farben, etc. First edition, Leipsic, 1866; second edition, 1887, Bruchstücke, etc., Leipsic, 1877.

‡ Optisches ueber Malerei. Vorträge und Reden, vol. i, Brunswick, 1884. Concerning

its true meaning—a fault of our vision—the painter is even placed in a position to reproduce the dazzling impression of the solar disk. Of this the Castle Gandolfo of Roqueplan in the Raczynski Gallery, through its boldness, affords an interesting example.

The representation of the stars as stars, in the shape in which the stars of decorations are drawn and from the resemblance to which star-fishes are named, rests likewise upon defects of our vision; for the stars of the sky are only shining points without rays, as indeed a few favored eyes see them. The sacred halo, the phosphorescence of holy heads, which in Correggio's Night extends over the whole Christ-child, and objectively illuminates the scene, has nothing to do with this. The origin of that kind of representation, so far as it is not a free sport of fancy, is possibly traced by Herr Exner to the crown of light which one sees in a dewy field in sunshine around the shadow of his own head.* By another defect of the human eye, astigmatism, the more advanced grades of which, such as short-sightedness, belong to pathology, Herr Richard Liebreich was able to explain certain peculiarities long incomprehensible, which disfigured the later works of the distinguished English landscape-painter, Turner.† It would have been easy for a modern oculist to protect him from this fault by properly fitted glasses. Color-blindness, known of old, but thoroughly studied only in our own age, is another very frequent defect of our vision, to which corresponds, in the ear, an inability to distinguish between the tones. A color-blind painter is perhaps not so inconceivable as a musician without hearing.

It might not be practicable to define the limits beyond which optical science can do no more good to the artist. In order to know the laws of the movements of the eyes, to understand wherein close vision is different from far vision, no painter will have reason to regret applying to himself Johannes Müller's remarks in his early paper on the Comparative Physiology of the Sense of Sight. Yet it must be granted that an artist could paint an eye very well without ever having heard of the Sansonian images, on which depends the soft glance of a mild eye as well as the wild fire of an angry, penetrating eye; just as the landscape-painter would paint the blue sky on his canvas no better if he had learned to take note of the yellow brush in every great circle of the heavenly sphere that passes through the sun, which continued unremarked through thousands of years, but has been familiar to physiologists since Haidinger's discovery.

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irradiation compare the Handbuch der physiologischen Optic, second edition. 5. Lieferung. Hamburg and Leipsic, 1889, pp. 394 *et seq.*

* Physiologisches und pathologisches in den bildenden Künsten. Vienna, 1889, p. 17.

† Proceedings of the Royal Institution, etc., weekly evening meeting, Friday, March 6, 1872.

In the much-debated question of the polychromy of the ancient statues and buildings, on the contrary, and of the propriety of adopting it, one observation of the physicists, as appears to me, has not hitherto been sufficiently considered. It is that all colors become whitish under a very strong illumination, so that, on the immediate view of the solar spectrum in the telescope, nearly every impression of color disappears, except for a light-yellow shimmer at the red end.* As the colors become whitish, their glaring contrast disappears, and they blend more harmoniously into one another. Therefore, under a clear sky, the fiery red petticoat of the Contadina, which is repeated so often in Oswald Achenbach's Campagna pictures, as well as the white horse of Wouverman's war-scenes, make no disagreeable impression on the eye. Under the bright Grecian sky, on the Acropolis, in the Poikile, the more or less glaringly painted façades and pillars still had a pleasant effect; in the gray northern light, and in closed rooms, they are not happily introduced.

Wheatstone has materially enriched the capacity of drawing and painting art from another side, by showing with his stereoscope the different manner in which binocular vision distinguishes nearer objects from monocular vision, and also from the binocular vision of objects so remote that the interval between the eyes vanishes before their distance. The impression of a solid body arises only when each of the eyes receives a different view of the object, and is produced by both views blending into one, the corporeal view. Therefore the painter, expressing dimensions of depth only through shading and air-perspective, has never been able to produce a real corporeal appearance on his canvas. While, then, Wheatstone's pseudoscope shows the human face concave in an unusual way, Helmholtz's telestereoscope exaggerates the distance between the eyes, and, without aërial perspective, resolves the far-off forest or mountain into its various elements. The stereoscope with movable pictures, however, confirms old Dr. Robert Smith's explanation of the fact that the moon and sun appear larger by nearly two tenths of their diameters in the horizon than in the zenith, and reduces the problem to the question why we see the vault of the sky rather flattened like a watch-glass than as a hemisphere.

Of vastly greater importance for art is photography, which originated at nearly the same time with the spectroscope. To fasten Della Porta's charming pictures was indeed a dream of artists as well as of physicists, and after the discovery of chloride of silver the no longer unattainable object came in sight. One

* Helmholtz, Handbuch der physiologischen Optic, A. a O. Fourth Part, 1887, pp. 284, 285.

would need to have witnessed Daguerre's discovery, and Arago's report upon it in the Chamber of Deputies, to realize the enthusiasm with which it filled the world. Daguerre's particular process, of only limited application, was soon cast in the shade by one which in its essentials is still in use. But it deserves, perhaps, to be remembered that when the first still imperfect Talbotype process reached us from England nobody foresaw its immense future, and the substitution for the silver plate of paper impregnated with a salt of silver was received with shaking of heads, and was looked upon as a step backward.

Thus photography started upon its wonderful career of victory. It soon assumed the relation to art that Arago had promised for it. Not only has it lightened the work of the architectural, interior, and landscape painter, and made the *camera lucida* superfluous even for panoramas; it has also furnished many useful hints relative to light and shadow, reflection and half-tone, and especially as to the way to give the most natural appearance of bodily projection to figures on a flat. It might be profitable, for the sake of forming a judgment in both directions, to inquire what part photography has had in the origin of the newer schools of painting, of the mannerism of the impressionists, and of the clear-light and free-light painters. It has taught the landscape painter how to reproduce rocks with geological and vegetation with botanical correctness, and to represent glaciers, which was rarely attempted before, and never successfully. It fixed the image of the clouds, although its pictures of the sky were somewhat defective. Finally, it helped the portrait painter without exciting his envy, for, while it caught up only a single often long-while tense expression, it was not adequate to give an average picture of the man, and the unpleasant, stiff photograph was almost proverbially a bad portrait. It furnished painters, however, in many instances with an invaluable groundwork, although it had to be enlivened by the artistic touch. But the newer form of portrait photography is calculated to attract the attention of the artist in many points. Instantaneous photography catches the expression of the countenance and the attitudes during so short an interval that it makes good what escapes in the average expression, and thus leads to most valuable observations. Duchenne and Darwin* recreated the doctrine of expression in emotion; the former by counterfeiting the various expressions by means of electrical stimulation of the muscles of the face, and the latter by following their phylogenetic development through the series of animals. Both presented the artist with photographic images of such expressions by the side of which

* The Expression of the Emotions in Man and Animals. London, 1872.

the drawings used in the art schools for the same purpose appear antiquated. Since then the English anthropologist, Mr. Francis Galton, has solved by photography a problem which was as much beyond the reach of the artist as the representation of the average expression of a person was of the photographer—namely, of collecting into a typical picture the average physiognomy and shape of the head of a considerable number of persons of the same age, race, like degree of mental development, or similar pathological condition or criminal propensity. This is done by causing faint pictures of faces of the same category to cover one another on the same negative.* Prof. Bowditch, of the Harvard Medical School, has in this way taken average (composite) pictures or the types of American students and girl students, drivers and conductors of horse-cars. In the last cases the superiority of the intellectual expression of the conductor type over that of the driver type is very plain. It would have been something for Lavater and Gall.

Again, pathology comes into the service of fine art. Dr. Charcot has recognized, in the photographically fixed convulsive attitudes and distortions of hysterics, the classical representations of possessed persons.† It is indeed most wonderful to see how Raphael, otherwise dwelling only in the ideal, portrayed in his Transfiguration the figure of the possessed boy so realistically that one can with certainty, from the Magendian position of his eyes, diagnosticate a central disease. It is in harmony with this, as was recently remarked in New York, that his left hand is afflicted with an athetoid cramp.‡

[*To be concluded.*]

EXPERIMENTS by Herr Regel with reference to the influence of external factors on the odor of plants show that the most important is the indirect influence of light on the formation of etheric oils and their evaporation. Heat and light intensify the fragrance of strongly fragrant flowers, which in darkness is lessened without quite disappearing. When the whole plant was darkened, those buds only which were before fairly well developed yielded fragrant flowers, the others were scentless. If, however, only the flowers were darkened, all were fragrant. Other plants open their flowers and are fragrant only by night. When these plants were kept continuously in the dark, they lost their scent, as they lost their starch. When brought into light again, both starch and fragrance returned. Besides light, respiration has a decided influence on the fragrance. In general, the opening of flowers coincides with their fragrance, but there is no necessary connection between these phenomena.

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* Inquiries into Human Faculty and its Development, with Illustrations. London, 1883.

† Compare Exner, a. a. O. S. 21 *et seq.*

‡ Sachs and Peterson, A Study of Cerebral Palsies, etc. Journal of Nervous and Mental Disease, May, 1890.

BACTERIA IN OUR DAIRY PRODUCTS.

By Prof. H. W. CONN.

THERE have been no discoveries in the last half-century more startling than those which are now accumulating upon the subject of bacteriology. Every one knows to-day that bacteria have a causal connection with certain diseases, and the whole civilized world has been recently agitated over the attempts that are being made to combat their effect in the human system. The study of the relation of these organisms to the animal body seems to be producing a revolution in the study of medicine, or rather perhaps is creating a science of medicine, for medicine of the past can hardly be called a science.

We have heard so much of the disease-germs and their evil effects that bacteria are usually looked upon as unmitigated nuisances. It is a doubtful chance if any knowledge of their beneficial effects has passed beyond the reach of the scientist's laboratory and lecture-room. But science has for a long time known that even the bacteria which are not connected with disease are of immense significance in the processes of Nature. The non-pathogenic germs were studied long before the pathogenic forms; but the great attraction offered by the study of disease has led the larger number of bacteriologists in this direction. To-day, however, we are beginning to recognize more than ever the great part played by the harmless bacteria, and to find out that their value in the world far outweighs the injury produced by their mischievous relatives. There is hardly a process in Nature which is not in some way connected with bacteria growth. Fermentation, the raising of bread, the formation of vinegar, the germination of seedlings, the growth of plants, the ripening of fertilizers, the decomposition of animal and vegetable bodies by means of which they are again incorporated into the soil, are all to a greater or less extent dependent on the growth of micro-organisms, either bacteria or yeasts. Without the agency of these organisms to prepare the soil, plants could not grow, and life would soon disappear.

There is no one who is not directly or indirectly connected with the dairy industry. The discoveries of the last twenty years, and more especially those of the last five years, have shown that dairy products are in a large measure connected with the growth of microscopic organisms—some dairy processes, indeed, being nothing more than gigantic breeding experiments. Each of the three chief products of the dairy—milk, butter, and cheese—has its own definite relations to bacteria growth and each must be considered separately.

MILK.—The souring of milk is such a universal phenomenon

that it has until recently been considered a normal character of milk. The last twenty years have, however, demonstrated for us that it is universally caused by bacteria growth. The souring of milk is simply the formation in it of a certain amount of lactic acid, and the acid precipitates the casein of milk just as any other acid would do, and thus forms the curd. But it is bacteria which produce the lactic acid. The presence of micro-organisms in milk was first noticed fifty years ago by Fuchs, but it was not till twenty years later that Pasteur succeeded in showing that these organisms could really produce lactic acid and thus might be the cause of the souring of milk. Fifteen years more were required to show that they were the sole cause of the souring of milk, and to demonstrate the further important point that milk when drawn from the healthy cow contains no bacteria and has therefore no tendency to sour or undergo other unpleasant changes. Since this was first shown by Lister, in 1873, numerous observers have so successfully verified the conclusions of Pasteur and Lister that no possibility of doubt longer remains, and we now know that under normal conditions the milk while in the mammary gland of the healthy cow is free from bacteria, and we have abundant proof that such milk will never sour nor ferment if kept free from bacteria contamination.

Absolutely pure milk is, then, free from bacteria; but when we examine milk that has been standing for a few hours the number of bacteria found in it is almost incredible. By the time that it is five or six hours old milk will contain millions for each tumblerful, and by the time it has reached the city consumer it will frequently contain fifty millions to the quart. Now, if the milk while in the cow contains no bacteria, it follows that this numerous crop must have been planted in the milk during the milking or subsequently. At first thought it seems hardly possible to believe that this immense number of bacteria could have found their way into the milk since the milking. But when we learn that they are abundant in the air; that they are crowded in every particle of dust clinging to the hairs of the cow; that they are always present in the milk-duct for a short distance from its opening, living there in the remains of the milk left from the last milking; that the milk-pail in which the milk is drawn can not be washed clear of them by any ordinary methods; that the milk-cans will always contain them in cracks and chinks even after the most thorough cleansing; that they are always on the hands of the milker; and when, in addition to all this, we learn that bacteria multiply so fast that by actual experiment a single individual may in the course of six hours give rise to three thousand progeny—it no longer remains a marvel that their number is so great in milk of a few hours' standing.

Fortunately, this immense number of bacteria in milk need not especially alarm us, for they are not disease-germs and are harmless to the healthy person. Nevertheless, they are undoubtedly a nuisance in the milk. They can not grow there without producing some effect upon it. Commonly the first change noticeable is the appearance of the well-known odor and taste of sour milk, followed shortly by its curdling. This souring is undoubtedly the result of bacteria growth, and it was at first supposed that there was a single definite species which alone had this power of producing lactic acid. So thought Pasteur and Lister at first, and such a species they described. The species of bacterium studied by them certainly had this power, and it was named *Bacterium lactis* by Lister. In later years the name *Bacillus acidi lactici* has been given to it. By the work of the last six years we have learned that more than one species has the power of souring milk by the formation of lactic acid. Lactic-acid formation is the characteristic of a class of bacteria comprising many species, and even in the ordinary souring of milk under normal conditions it is not always the same species of bacteria which produces the mischief.

While it is true that any one of a number of species of bacteria may produce lactic acid by their growth in milk and thus cause its souring, in other respects these different species do not have the same effect. The formation of lactic acid is not the only change that occurs in the souring of milk. Sour milk has a well-known odor, but this is not due to the lactic acid, since lactic acid is odorless. The formation of such an odor tells us, therefore, that there are other changes going on in the souring of milk. The fact is, that a decomposition of the albuminoids and other substances in the milk is going on, and it is these decomposition products that give the odor. Now, the different species of bacteria do not all produce the same sort of decomposition products. All who are familiar with milk will recall that the character of sour milk is by no means uniform. It differs in the hardness of the curd, in the amount of the whey, in odor, and even in taste. When different specimens of milk are examined just before or just after souring, it is found that the species of bacteria are by no means the same in the different specimens. Each will contain some of the acid-forming class, but the particular species which happen to be present in the different specimens will vary with the different conditions. Different localities and different methods of handling the milk will affect the variety of bacteria that it contains. It will sour in all cases, since all have some of the members of the acid-forming class; but the other accompanying phenomena may be different. Thus we have learned to attribute all the differences in the different specimens of sour milk to the fact that the souring

has been produced under the influence of different species of bacteria. The souring of milk is therefore not a simple or a uniform phenomenon. While it is always the effect of bacteria growth, we recognize many varieties of souring corresponding to the variety of bacteria most abundant in the milk before souring. All this makes little difference to the consumer; in any case the milk is ruined for his purposes, and he is more concerned in preventing such troubles completely than in learning their variety. A remedy seems simple enough. When we have once learned that the whole trouble is caused by bacteria, we see that it is only necessary to keep these organisms out in order to preserve the milk pure and sweet.

From the standpoint of public health also the desirability of freeing milk from these organisms is becoming every day more apparent. It is true that the vast majority of the bacteria in milk are perfectly harmless to the healthy person, even when swallowed in such numbers as above indicated. But, at the same time, it not infrequently happens that disease-germs get into the milk and, finding there a suitable medium for growth, multiply rapidly. They are then served out to all the patrons supplied with the milk. Typhoid fever is certainly disseminated by means of the milk-supply, and there is a growing conviction that the fatal tuberculosis owes much of its prevalence to milk from diseased cows. Other epidemics have also been traced to the same source.

Even if no definite disease-germ chances to be present in the milk, the vast number of harmless forms may render the milk dangerous to all having weak or sensitive digestive organs; for they produce considerable lactic acid, and every one knows that acid is injurious in the food of infants and invalids. The presence of lactic acid is probably a less serious matter than the presence of certain decomposition products which are formed by the same bacteria. These are directly poisonous, and, although they are present in such small quantities that they have no effect on the healthy person, they may be injurious to one whose digestive organs are in a sensitive condition. For a long time doctors have recognized that boiled milk is a safer food for invalids than raw milk, supposing, however, the explanation to be that the cooking renders it more easily digested, just as it does other foods. Recent experiments have shown us that this is not true. On the contrary, boiled milk is less easily digested and absorbed by the system than raw milk. The real reason for the greater safety in drinking boiled milk lies in the fact that it is thus deprived of the disturbing action of the millions of bacteria ordinarily present.

To keep bacteria out of milk is a practical impossibility. Their presence in such quantities in all places renders their access

to it a certainty, and it has only been by exercising the most extraordinary precautions that scientists have in a few cases succeeded in obtaining milk directly from the cow in such a way as to avoid its becoming contaminated during the milking. At the same time much may be accomplished by cleanliness in the barn and the dairy. The presence of disease-germs in the milk is always to be traced to filth or to carelessness in handling the milk, or to diseased cows. Typhoid-fever germs, for instance, can only get into the milk from some unusual source, and tuberculosis germs only from diseased cows. If it were possible to enforce cleanliness in the barns and dairies, and to obtain sufficient care in the handling of milk, we should have no more epidemics spread through the milk-supply. But, in the present state of public ignorance and carelessness as to health, such an enforcement is an impossibility. In our cities and large towns, therefore, the milk-supply must be looked upon as one of the fertile sources for the spread of disease, and it behooves every one to look carefully to the condition of the milk he drinks during times of epidemics, especially of those affecting the digestive organs.

But even with the most extreme care it is impossible for our milkmen to avoid the presence of the more common forms of micro-organisms which will sour the milk. Recognizing, then, that bacteria are sure to get into the milk, we may next ask if there is no way of destroying them after they get in. If we can kill these bacteria, we can of course preserve the milk longer and render it more healthful. It is easy enough to kill the bacteria though every method is open to certain objections. Various chemicals have been suggested for poisoning the bacteria, or at least for delaying their growth, but they are one and all to be condemned, as likely to do more harm than good.

A safer and more effective method for preserving milk is by the use of heat. All bacteria may be killed by heat, and then, if the milk be kept in tightly closed bottles, it will keep sweet indefinitely. For this purpose many sterilizing machines have been invented in the last few years, all based upon the same principle, but differing much in detail. In all cases the milk is subjected to a high heat. Most of them simply heat the milk to a boiling temperature by means of steam or boiling water, but a few, by boiling under pressure, contrive to raise the temperature considerably above boiling water. Although many forms of apparatus have been devised for simplifying the matter, no apparatus is really needed for sterilization. All that is necessary is to put the milk into bottles and boil it for ten minutes with the mouth of the bottle open, then close the mouth and steam it for ten minutes more. This method of sterilization will not kill all of the bacteria in the milk, but it will kill all the disease-germs which are likely

to be in it, and it will so decrease the numbers of the other bacteria that the milk will keep sweet for a long time.

All methods of sterilization that are in use in this country have the disadvantage of giving to the milk the taste which is peculiar to boiled milk, and also of rendering it less easily absorbed by the body. In France and Germany a method has been adopted which accomplishes the purpose without injuring the taste of the milk. Machines are in use in Paris and some other cities which will heat great quantities of milk to a temperature of about 155° Fahr. for a few minutes, and then cool it rapidly to a low temperature. The method has been called the pasteurization of milk. It does not kill all the bacteria, but it does destroy so many of them that it greatly increases the keeping properties of the milk. Moreover, it almost entirely destroys the danger from disease-germs in milk, since nearly all forms likely to occur in milk are killed by this temperature. The advantage of this method is that the temperature of 155° Fahr. does not give to the milk the taste of boiled milk, which most people find unpleasant, and does not render the milk difficult of digestion. These pasteurizing machines have not yet been introduced into this country, and the opportunity exists for some one to develop a thriving business by furnishing pasteurized milk in our large cities. A little experience with its superior keeping properties, and a little knowledge of its greater wholesomeness, would soon create a demand for it in America as it has already done in the larger cities of France and Germany.

BUTTER.—If bacteria are the enemies of the milkman, they are the allies of the butter and cheese maker. The last few years have shown us that butter owes at least its flavor to bacteria growth in the cream. Butter is made by allowing the cream to separate from the milk by means of its less specific gravity, and then by shaking the cream vigorously until the butter collects in lumps. Now, it has been for a long time recognized that it is a difficult matter to churn sweet cream. It may be shaken for a long time without the separation of the butter, and a smaller amount of butter can be obtained from it than from cream that has been allowed to sour or "ripen" for a time before churning. This, at all events, is true of cream which is separated from the milk by the ordinary method of setting, though it seems less true of cream separated by means of a centrifugal machine. It has also been generally recognized that the butter made from sweet cream lacks the delicate flavor or aroma which is such an important factor in a first-class butter. Sweet-cream butter has a flat, creamy taste, which is not generally desired.

For these reasons butter-makers have learned not to churn cream when fresh, but to allow it to stand awhile and sour, or

"ripen." The cream in a creamery is placed in large vats, and then kept at a constant warm temperature for about twenty-four hours. The cream is stirred frequently during this time, and at the end of the ripening it is seen to have changed its character. It is somewhat acid in taste, is slightly thickened, and has a pleasantly sour odor, though one quite different from that of sour milk. The cream is now churned, and the butter is found to separate readily, the quantity is at its maximum, and the butter obtained has the proper butter aroma.

Bacteriological study of the last few years has shown that this "ripening" is nothing more than a breeding of bacteria on a large scale. There were many bacteria in the cream at the beginning, and the ripening has been conducted at just the temperature at which bacteria grow rapidly. The result is, that their multiplication is marvelously rapid, and the number of bacteria present in ripened cream is beyond comprehension and almost beyond calculation. Five millions in a drop would not be too high an estimate for some specimens.

Now, what are the bacteria doing in the cream during their twenty-four hours' growth? They can not multiply so rapidly without producing profound changes in the cream. So far as the butter-maker is concerned their action is twofold: 1. There is produced in the cream a considerable amount of lactic acid, together with small quantities of other acids. 2. Various decomposition processes are going on which fill the cream with decomposition products, and these give rise to the odor and taste of ripened cream.

To understand the effect that this ripening has upon the butter-making, we must first ask what happens to the cream during the churning. If we look at a drop of milk under the microscope, we find that the butter-fat is in the form of the most minute drops. So small are they that they can not be readily separated from the liquid part of the milk. In cream we simply have the great mass of these drops together, but still not at all fused, like a lot of snow-balls floating in water. In the churn, however, the cream is agitated until the drops are shaken together and made to fuse with each other. They now form masses of fat large enough to be removed from the liquid in which they float, and these masses form the butter. But, looking at the cream more closely, we find a mechanical difficulty in the way of their ready fusion. The fat-drops are not free to move at will, for they are bound together in groups by a sort of slimy substance. As we watch the cream with our microscope we see the fat-globules are not easily shaken together, for the slimy matter prevents their direct contact. This slimy substance must be broken down and the drops shaken into each other before the butter can form into

the large masses necessary for their separation from the liquid. It requires a deal of shaking to accomplish it when the slime is intact, and sweet cream may sometimes be churned for hours without producing the butter. But the ripening prepares the way for the churning. The acid formed by the bacteria gradually dissolves this slime, which is of an albuminous nature, and after it is thus dissolved the difficulty of the fusion is gone and a short shaking in the churn finishes the process. It is plain, too, that a larger amount of butter will be obtained from the cream, for in churning sweet cream much of the fat will be left behind in the form of small drops not to be separated from the slime even after the most vigorous churning.

As mentioned above, the second advantage derived from ripening is the development of the aroma of a first-class butter. Sweet-cream butter is tasteless, and the cause of the butter aroma is to be found in the decomposition products of bacteria growth. While growing in the cream they are splitting up the sugars and albuminoids present and producing decomposition products. Among them are many volatile products which have a prominent odor and taste, and these, as we have seen, produce the odor and taste of ripened cream. Now, of course, the butter obtained from such cream will be affected by these compounds, and thus we see that the delicate aroma of first-class butter is produced by the decomposition products of bacteria growth in the cream. These are volatile, and eventually pass away from the butter in large measure. It is well known that the delicate butter aroma is found only in fresh butter. Old butter is strong enough in its taste, but the peculiar delicate aroma is gone. When first made, however, these volatile substances permeate the butter and explain its flavor. Of course, it is highly essential that only the proper decomposition products should be developed, and for this reason it is a matter of high importance that the ripening shall be stopped at just the right time. If it is not continued long enough, the proper decomposition will not take place; and, on the other hand, if it is continued too long, the volatile products will approach those of putrefaction and give a strong-tasting butter. At just the right moment they are present in sufficient amount to give the butter a pleasant flavor without being so abundant as to give a disagreeable one. The experience of the butter-maker guides him in determining when to stop the bacteria growth, and here is one of the points of skill in butter-making. When the cream is ripe enough he churns it, and this ends the process, so far as the bacteria are concerned, for they cease to grow when the butter is made.

But why should they cease to grow? Why do they not continue to cause the decomposition in the butter? What becomes

of them after the churning? The answer to these questions is simple. Many of the bacteria go off in the buttermilk; many more are removed by the water used in washing, but many of them still remain in the butter. Here, however, their active life is nearly over, for the salt added to the butter checks their growth and their numbers begin to diminish. Butter is not a good medium for their development, and, after a few weeks, they practically disappear. Their growth in the butter is thus so slight that it is of no importance and ordinarily produces no noticeable result. To be sure, the butter may subsequently become rancid, and until recently it has been supposed that the rancidity of butter was due to bacteria growth. Some species of bacteria certainly produce butyric acid, and this is one of the most prominent characteristics of rancid butter. But it has been recently shown that butter may become rancid independently of bacteria growth, the direct oxidizing power of the air producing the effect. Bacteria, it is true, may hasten the process, but they are probably not a necessary cause. After the butter is made, then, the bacteria are of no further importance, and unless there should chance to be some disease-germs among them nothing further will result from their action.

The butter-maker thus forces the bacteria to give to his butter a flavor for which he gets a good price in the market. Unfortunately for him, however, there is more than one species of bacteria which may readily get into his cream and produce its ripening, and not all of them are equally serviceable to him. Many species of bacteria give a very unpleasant flavor to the butter if they are abundant in the ripening cream. While they cut the slime that holds the fat-globules and thus make the churning easy, the aroma produced by different species is by no means always satisfactory. It has been found that many of the species which commonly grow in ripening cream will produce very disagreeable butter if they are allowed to act alone. Others acting alone produce good butter, and the latter must, of course, outweigh the former, or the butter will be unsatisfactory.

The fact is, that during the ripening of the cream a great battle is going on among the different species of bacteria. Some of them find the conditions of the ripening cream favorable to their growth, while others find it less favorable. The favored species multiply rapidly, and may largely crowd out of existence those less favored. Some species may chance to get the start of others by being in greater numbers at the outset, while another species will make up for all drawbacks by having a more rapid rate of multiplication. The final result of the struggle will depend upon an infinite variety of conditions, which will be entirely beyond our knowledge. The condition of the cow, the manner of

milking, the manner of setting the cream, the temperature, etc., will all be important factors favoring one form of bacteria and hindering others. If the battle results in favor of the beneficial species, a good-flavored butter will result, while, if the injurious species should get the upper hand, the butter will be bad. The results are at present beyond the control of the butter-maker. By practice he has found the methods which will commonly result in a good product; but even with his greatest precautions he is occasionally unable to obtain the best butter. At certain seasons of the year failure to obtain good butter is about as common as success even in our best creameries.

Now, bacteriologists would not pretend that the bacteria content of the ripening cream is the sole reason of the variations in the quality of the butter product. Different conditions of the cattle, different food, etc., will all affect the butter, but beyond doubt bacteria have an important part to play. Now, uniformity in the product of the dairy is the great desideratum of the butter-maker. Usually he can make good butter, but sometimes he fails from unexplained causes. The complexity of the ripening process makes it impossible for him to be sure of uniformity in this respect, even though other conditions are constant. But what is to prevent the bacteriologist finding the right bacteria to produce a proper aroma to the butter and furnishing them in quantity to the butter-maker to use in time of trouble? They may then be planted in the cream, and thus a ripening always assured which shall be of the best character. It seems to be entirely possible thus to produce uniformity in this direction. Already in Germany and Denmark and in this country experiments have been started looking in this direction with much promise of success. It is not unlikely, therefore, that before long the butter-maker will have at his command a method of assuring success in the aroma of his butter if he only exercises ordinary skill in the process of its manufacture. If such an artificial ferment may be obtained, uniformity in the ripening of cream will be easy. Perhaps the result will be to bring the different creameries into greater likeness to each other, enabling those which now are unable to obtain a first-class product to improve its flavor by using the right species of bacteria for ripening in the place of the inferior species which are afforded by some localities. This would perhaps not improve the best qualities of butter, but would bring the inferior qualities to a higher standard.

CHEESE.—If bacteria are an aid to the butter-maker, they are absolutely indispensable to the cheese manufacturer. Some people do enjoy the taste of sweet-cream butter, and there has been for some time an evident tendency toward a desire for less strongly tasting butter. But no one desires to eat fresh cheese. When

first made, cheese is soft and tastes somewhat like milk curd. It has none of the palatable taste which we find in the cheese of our table. It is a long ripening which gives this taste to the cheese.

Here, again, the ripening process is one of bacteria growth. The millions of bacteria that were in the milk are stored away in the cheese, and instead of being killed here, as they are in the butter, they begin to multiply immediately. Here, too, there is a battle of bacteria, and now one species is in the ascendency and now another. If the wrong species gets the upper hand, the cheese becomes bad, and cheese-makers have their greatest trouble from this source. The bacteria do not grow so rapidly as they do in cream, for the conditions are less favorable, but the ripening is kept up for months, and during the whole time the bacteria are growing. Under their action the character of the cheese slowly changes. Here, again, the decomposition products are responsible for the taste and odor. In some cases, such as Limburger cheese, the action is allowed to continue to the verge of putrefaction. Ordinarily it is not continued so far, but in all cases the cheese-maker favors the growth of certain forms of bacteria by regulating the temperature at which the ripening is carried on. As the ripening continues, certain parts of the cheese are digested and decomposed by the bacteria growth, and, as the products of decomposition accumulate, the taste grows stronger. After a time it is considered fit for the market, but the longer the ripening continues the stronger the taste becomes.

Little is known yet as to the bacteriology of different kinds of cheeses. Whether the different tastes of Edam, Limburger, and other characteristic cheeses is largely due to the character of the bacteria ripening them can not yet be said. Cheese-makers do, however, have much trouble with various irregular forms of ripening, and a great drawback in this business is the lack of uniformity in this respect. Beyond doubt this is due largely, perhaps chiefly, to the variety and number of bacteria which succeed in gaining a foothold in the cheese and contribute to its ripening.

Along the line of cheese manufacture our bacteriologists are promising us help from their researches. Of course, the cheese-maker has never paid any attention to the sort of bacteria which he plants in his cheeses, for he has never heard of them. Sometimes he has unwittingly planted species which produce violent poisons, as is shown by the many instances of death from eating poisonous cheese. Now, our bacteriologists are suggesting that the ripening of cheese may be easily controlled. Artificial cultures of the proper sort may be furnished the cheese-maker, and if these are planted in the cheese not only will the danger from poisonous cheese be prevented, but at the same time the desired taste of the cheese be assured. More than this, when we recognize

the great variety of decomposition products which the different species of bacteria produce, we can see ahead a great development in the varieties of cheese. Who can tell what may be the numerous varieties of cheeses produced when our cheese-makers have learned to ripen their product with pure cultures of different species of bacteria, instead of depending as they do now upon "wild" species which get into the cheese by accident from the milk!

THE GREAT EARTHQUAKE OF PORT ROYAL.

By Colonel A. B. ELLIS.

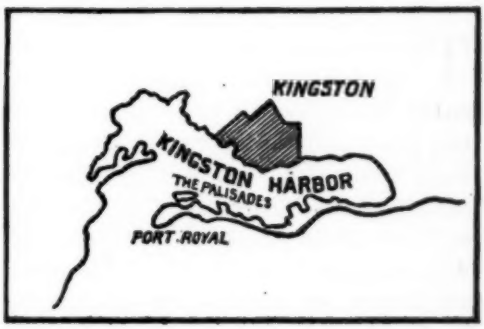
THE popular notion of the great catastrophe which overtook the city of Port Royal, Jamaica, in the year 1692, is that the earth yawned open, taking in the unfortunate city, as it were at one gulp, and that the next minute the sea flowed several fathoms deep over the spot where it had stood. Connected with this notion is the belief, which has been sedulously inculcated by several generations of religious writers, that the catastrophe was a signal instance of divine wrath; that, in fact, the city was swallowed up on account of the desperate wickedness of its inhabitants—the buccaneers and their associates. It is somewhat strange that in this age of investigation and research no one should have yet come forward to dispel some of the illusions with which ignorance and superstition have clothed this great disaster; for we may confidently affirm that the earth did not yawn open and swallow up the town of Port Royal, which was destroyed in a perfectly natural and comprehensible manner; and to those persons who profess to be exponents of divine motives we may point out that Port Royal was not overwhelmed when it was the resort of the buccaneers and the dissolute and profligate of both sexes, but at least fifteen years after these gentry had been expelled from Jamaica, and had removed their headquarters to the French portion of Hispaniola.

The former city of Port Royal stood where the present town now stands, at the western extremity of the long tongue of sand, called "The Palisades," which incloses the harbor of Kingston on the southern side. Its area in 1692 was much the same as it is now; for, except on the northern side, where the church buoy marks the site of the submerged cathedral, the action of the tides has in a great measure repaired the damage committed by the earthquake. The accompanying map will enable the reader to see its situation and surroundings at a glance.

The sand-spit, some nine miles in length, called "The Palisades," at the extremity of which Port Royal stands, owes its existence to

a number of small cays of Æolian formation, which, originally detached, have now been joined together by ridges of sand. This formation is still going on to the southward, and an outer line, similar to the Palisades, is gradually being built up on the numerous small detached cays which lie between East and Southeast Cays.

When the Spaniards discovered Jamaica the present Palisades were in much the same condition as the outer line is now—that is to say, there was a line of detached cays, connected by banks of loose, shifting sand, which were submerged at high water, with here and there channels of sufficient depth to admit of the passage of small vessels. In 1635, when Colonel Jackson, the English adventurer, attacked and plundered St. Jago de la Vega, the capital of Jamaica, the small cay of calcareous rock, which ultimately became the nucleus of Port Royal, was separated from the Palisades by a channel sufficiently deep for his ships to pass through. Twenty years later, when Venables captured the island from the Spaniards, this channel was closed by a narrow bank of sand barely rising above the water, and those who had accompanied the former expedition remarked upon the change which had taken place. From that date the sand seems to have accumulated rapidly, and before long the Palisades became one continuous tongue of sand, extending from the mainland of the island on the east to Port Royal Point on the west.



The Spaniards, during the century and a half that they held Jamaica, never erected any buildings upon Cagua, or Punto de Caguaya, as the cay at the western extremity of the Palisades was termed by them.* Indeed, in their day the site was not at all suitable, for during the prevalence of strong breezes the sand was swept hither and thither by the sea, and a great portion of the cay submerged. After, however, the cay had become joined to the Palisades, and the sand ridge had risen two or three feet above high water, Cagua, or Careening Point, as the English called it, became a good position from which to defend the entrance of the harbor. The first work, which mounted twenty-one small guns, but consisted merely of a stockade with a wall of

* This name is supposed to be a corruption of *caragua*, the Indian name for the aloe.

loose stones, was erected in 1656, and in 1657 this was replaced by a round tower of stone. The requirements of the small garrison gradually led to houses being built, and Governor Brayne formed a naval and military depot. Thus by degrees a town sprang up, which at first was limited to the rock area of the original cay, but which gradualy overflowed those limits and spread along the sand which had drifted up against the rock. In 1660, at the accession of Charles II, the royal commission confirming in the office of Governor of Jamaica Colonel D'Oyley, who had been appointed under the Commonwealth, was proclaimed at Careening Point, and the town was named Port Royal, in commemoration of the event. In 1662 the stone tower, which had been enlarged and added to, was similarly renamed, and henceforward was known as Fort Charles.

At about this time the buccaneers began to frequent Port Royal, bringing there their prizes and plunder, and the prodigality and excess of these gentry drew a number of dissolute characters to the town. The buccaneers themselves formed no inconsiderable number. Morgan, the English (or, rather, Welsh) leader, had under his command twenty-eight English vessels, carrying one hundred and eighty guns and thirteen hundred and twenty-six men, and eight French vessels with fifty-nine guns and five hundred and twenty men, and there were several other independent leaders. The wealth they brought into Port Royal was enormous. After the sack of Puerto Velo, the successful buccaneers returned to Jamaica and divided the spoil on Port Royal beach. "Two hundred and fifty thousand pieces of eight were divided among them, and plate, jewels, and rich effects were piled up beneath the eaves of the houses for want of warehouse room. This quickly changed hands, and after a few weeks of riotous debauchery the buccaneers were again poor, and clamoring to be led to sack another town. . . . Many of the inhabitants of Port Royal were literally rolling in wealth. Their tables and dinner services were of silver, and their horses were sometimes shod with plates of the same metal, loosely nailed, so as to drop off and show their contempt of riches. Vast wealth, intermingled with the sound of arms and the riot of intemperance, filled the streets."

Esquimeling, the historian of the buccaneers, who was bondservant to the notorious Morgan, has left us a strange picture of Port Royal at that day. After narrating a successful exploit, he continues: "All these prizes they carried into Jamaica, where they safely arrived, and, according to their custom, wasted in a few days in taverns and stews all they had gotten by giving themselves to all manner of debauchery, with strumpets and wine. Such of these pirates are found who will spend two or three thou-

sand pieces of eight in one night, not leaving themselves, peradventure, a good shirt to wear on their backs in the morning. . . . My own master would buy on like occasions a whole pipe of wine, and, placing it in the streets, would force every one that passed by to drink with him, threatening also to pistol them in case they would not do it. At other times he would do the same with barrels of ale or beer. And very often, with both his hands, he would throw these liquors about the streets and wet the cloaths of such as walked by, without regarding whether he spoiled their apparel or not, were they men or women."

To Port Royal, consequently, flocked thousands of people, all anxious to profit by the wild extravagance of the buccaneers, and new houses sprang up until all the available space was covered. Then rows of palisades were driven a few feet into the sand at the water's edge, sand was brought from a distance and banked up behind them, and houses built on the foundation thus made. As the demand for greater space increased, such encroachments became more common, until the greater portion of the town was built upon made ground, which was merely kept in position by a succession of rows of stakes or palisades, and which any severe shock of earthquake would inevitably shake down. And this was done, not on a flat beach shelving gradually through shallow into deep water, but on the brink of a harbor so deep that the largest ships of the day could lie close in shore, sometimes even with their yards projecting over the roofs of the houses. It was simply courting destruction.

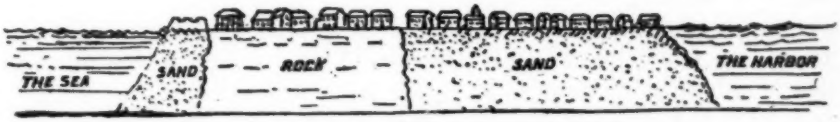
However, we are anticipating, for the end was not yet. The buccaneers continued to frequent Port Royal, in spite of orders sent out by the British ministers to the Governor of Jamaica to restrain their excesses, and the plunder of Maracaibo, Panama, and scores of less important places was brought into the town. The buccaneers were in fact the masters of the situation, for the Jamaica government had no force with which it could compel respect for its orders—that is to say, if it gave any orders, for there are good reasons for supposing that everybody was disposed to connive at a system by which everybody profited. At last, however, the remonstrances of the court of Spain took effect: in 1672 all commissions and letters-of-marque that had been granted to buccaneers were revoked, and Port Royal ceased to be their chief resort, though for the next two or three years occasional prizes were brought in by stealth. With the departure of the buccaneers the town declined; and when Sir Hans Sloane visited it in 1687, although it contained some two thousand houses, the population was only between three and four thousand. The bulk of the inhabitants had no doubt followed the fortunes of the buccaneers, but the town was still the largest and most populous in

Jamaica, all the others, with the exception of Spanish Town, being mere hamlets.

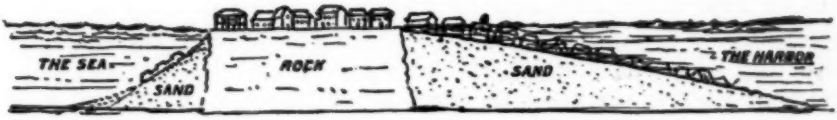
Let us now take a general view of the town as it was a year or two before the earthquake. In the center, approximately speaking, built on the solid rock of the original cay, was Fort Charles and about five streets of houses, while all around, but principally to the north, and to the east, where the ship-channel had been when Colonel Jackson visited the island, the greater part of the houses were built upon ground that had been won from the sea, and was retained in position by rows of palisades. These latter were most numerous to the east, and that part of the town was called the Palisadoes, whence we get the modern name "The Palisades." Several batteries and other works had been built on the brink of the water on land similarly won from the sea. Of these the principal were Fort Rupert, a hexagonal work, defending the approach along the sand-spit from the east; Fort James, which mounted thirteen guns, and was situated at the northwestern angle of the town; Walker's Lines, which commanded the entrance to the harbor; and Morgan's Lines, which defended the sea front. The ground-floors of the houses were, generally speaking, of brick; the upper portions of wood. Four fifths of the town was thus built upon sand, heaped up on the verge of deep water, and it is marvelous how the inhabitants could have been satisfied to live in so perilous a position, for earthquakes frequently took place, and they had ample warning of what might at any time occur. On October 20, 1687, a shock of earthquake was felt which caused the bells in the church to ring and a tidal wave to sweep along the streets nearest the harbor, while the sand in other streets, sucked out by the waters beneath, fell away into crater-like pits. Nobody, however, seems to have inquired what would have been the result had the shock been of longer duration.

The 7th of June, 1692, the day of the great earthquake, was exceedingly hot; not a cloud was in the sky, and not a breath of air stirred. At about 11.40 A. M. a slight trembling of the earth was felt, and this was shortly followed by a second shock, somewhat stronger than the first, and accompanied by a hollow rumbling noise like distant thunder. At this most of the people began to run out of their houses, but a third shock at once supervened, and in about a minute—for it is said to have lasted nearly a minute—four fifths of the town was in ruins and the sea rolling over it. The streets on the north side, on the brink of the harbor, where the sand had been most steeply banked up, were the first to fall, sinking at once into four or five fathoms of water; next fell the church and tower; and then Morgan's Lines, on the south side, on the verge of the sea, to which many had fled for safety,

suddenly disappeared, the sea rolling completely over the place where it had stood. Then the whole of that portion of the town where the ship-channel had been sank at once into deep water, while the houses nearer the central rock sank, some up to the eaves, others up to the first floor, and others again one or two feet only, according to the distance at which they were situated from the water's edge. The shock of the earthquake, in fact, shook down the artificially sustained bank of sand; as the sand shook down and spread out, the houses subsided, while the sea, rushing in underneath as well as above, gushed up in spouts in the streets and completed the ruin. Fort Charles and the houses that stood on the rock foundation alone remained, and of these the greater number were terribly shattered. About sixteen hundred persons are said to have perished. The following sketches, showing roughly a section of Port Royal, before and after the earthquake, will help to explain what occurred.



BEFORE.



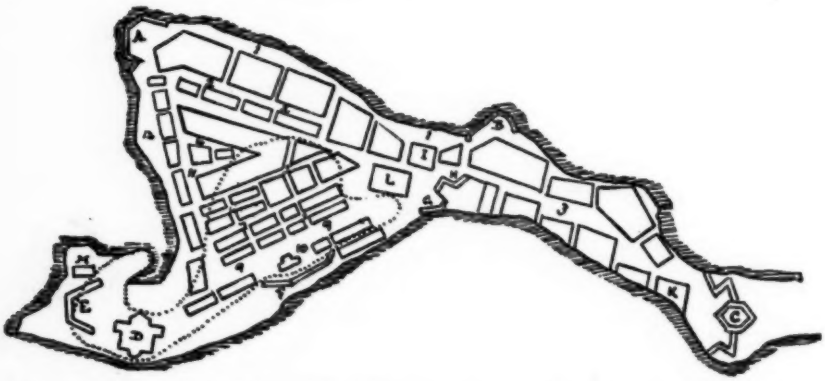
AFTER.

The amount of damage done by an earthquake to buildings depends very largely upon the nature of the foundations, for the shock-waves of earthquakes travel at different rates of speed through different substances. As a rule it may be said that the more compact the substance the quicker the rate. Thus they travel fastest through solid rock and slowest through loose sand. The duration of the shock has everything to do with the amount of damage; consequently, in Port Royal, the sand gave way, and the houses built on it collapsed, while those built on the rock, though evidently shaken and thrown out of the perpendicular, remained standing.

We are able to append the following curious map, which is said to be an exact plan of Port Royal before the earthquake, and which shows what remained afterward. It must be observed, however, that the cathedral-church, which stood near the building known as King's House, is unaccountably omitted. The original is to be found in the library of the Institute of Jamaica, at Kingston. The dotted line shows the area of rock.

A few descriptions of the earthquake by eye-witnesses are still extant. We take the two following, which may be of interest, from the Philosophical Transactions, vols. xvii, xviii, 1694:

1. "This part of Port Royal which is now standing, is said to stand upon a rock. . . . It seems strange that the force of the earthquake did not dissipate and dissolve the very foundation of it, and that it did not fall to pieces and scatter under the water, as the rest of the place did; for the shock was so violent that it threw people down on their knees, and sometimes on their face, as they run along the street to provide for their safety; and it was a very difficult matter to keep one's legs. The ground heaved and swelled like a rolling, swelling sea ('tis a strange comparison, but everybody here using it, I venture to do so likewise), by which means several houses now standing were shuffled and moved some



AN EXACT PLAN OF THE TOWN OF PORT ROYAL BEFORE THE EARTHQUAKE IN 1692; THE PART WITHIN THE DOTTED LINE BEING ALL THAT WAS LEFT AFTER THE SHOCK.

A, Fort James; B, Fort Carlisle; C, Fort Rupert; D, Fort Charles; E, Walker's Lines; F, Morgan's Lines; G, White's Lines; H, Church Lines; I, King's House; K, School; L, New Dockyard; M. Storehouse. 1, Thames Street; 2, Queen's Street; 3, High Street; 4, Broad Street; 5, New Street; 6, Cannon Street; 7, York Street; 8, Tower Street; 9, Church Street; 10, Parade; 11, Lime Street; 12, Fisher's Street.

yards from their places. One whole street (a great many houses whereof are now standing) is said to be twice as broad now as before the earthquake; and in many places the ground would crackle and open, and shut quick and fast: of which small openings I have heard Major Kelly and. others say they have seen two or three hundred at one time, in some whereof many people were swallowed up; some the earth caught by the middle and squeezed to death; the heads of others only appeared above ground; some were swallowed quite down, and cast up again by great quantities of water; others went down and were never more seen. These were the smallest openings; others that were more large, swallowed up great houses; and out of some gapings would issue whole rivers of water, spouted up a great height into the air,

which seemed to threaten a deluge to that part of Port Royal which the earthquake seemed to favor, accompanied with ill stenches and offensive smells. . . . The sky, which was before clear and blue, was in a minute's time become dull and reddish, looking (as I have heard it compared often) like a red-hot oven: all these dreadful circumstances occurring at once, accompanied all the while with prodigious loud noises from the mountains, occasioned by their falling, etc.; and also a hollow noise underground, and people running from one place to another distracted with fear, looking like so many ghosts, and more resembling the dead than the living, made the whole so terrible, that people thought the desolation of the whole frame of the world was at hand. Indeed, 'tis enough to raise melancholy thoughts in a man now, to see the chimneys and tops of some houses, and the masts of ships and sloops, which partak'd of the same fate, appear above water; and when one first comes ashore, to see so many heaps of ruins, many whereof by their largeness shew that once there had stood a brave house; to see so many houses shatter'd, some half fallen down, the rest desolate and without inhabitants; to see where houses have been swallowed up, some appearing half above ground, and of others the chimneys only; but above all to stand on the sea-shore, and to look over that part of the neck of land which for above a quarter of a mile was quite swallowed up; there where once brave streets of stately houses stood, appearing now nothing but water, except here and there a chimney."

2. "What you desire concerning our earthquake in Jamaica, I will answer as near as I can to what I saw and heard; Port Royal being the place where I lived. I shall begin with what I met with there. On Tuesday, the 7th of June, 1692, betwixt eleven and twelve at noon, I being at a tavern, we felt the house shake, and saw the bricks begin to rise in the floor, and at the same instant heard one in the street cry, 'An earthquake!' Immediately we run out of the house, where we saw all people with lifted-up hands begging God's assistance. We continued running up the street, whilst on either side of us, we saw the houses, some swallowed up, others thrown on heaps; the sand in the street rose like waves of the sea, lifting up all persons that stood upon it, and immediately dropping down into pits; and at the same instant a flood of water breaking in and rowling those poor souls over and over; some catching hold of beams and rafters of houses, others were found in the sand that appeared when the water was drained away, with their legs and arms out; we beholding this dismal sight. The small piece of ground whereon sixteen or eighteen of us stood (praised be God) did not sink. As soon as the violent shake was over, every man was desirous to know if any part of his family were left alive. I endeavoured to go towards my house

upon the ruins of the houses that were floating upon the water, but could not; at length I got a canoa, and row'd up the great sea-side towards my house, where I saw several men and women floating upon the wreck out to sea; and as many of them as I could I took into the boat, and still row'd on till I came to where I thought my house had stood, but could not hear of neither my wife nor family. But seeing all people endeavouring to get to the island, I went among them, in hopes I might hear of my wife, or some part of my family, but could not. Next morning I went from one ship to another, till at length it pleased God that I met with my wife and two of my negroes. I then asked her how she escaped. She told me, when she felt the house shake, she ran out and call'd all within to do the same. She was no sooner out but the sand lifted her up; and her negro woman grasping about her, they both dropped into the earth together; and at the same instant the water coming in, rowl'd them over and over, till at length they catch'd hold of a beam, where they hung, till a boat came from a Spanish vessel and took them up. The houses from the Jews' street end to the breastwork were all shak'd down save only eight or ten that remained from the balcony upwards above water. And as soon as the violent earthquake was over, the watermen and sailors did not stick to plunder those houses; and in the time of their plunder one or two of them fell upon their heads by a second earthquake, where they were lost. . . . Several ships and sloops were over-set and lost in the harbour. Amongst the rest the Swan-Frigat that lay by the wharf to careen, by the violent motion of the sea and sinking of the wharf, was forced over the tops of many houses: and passing by that house where my Lord Puke lived, part of it fell upon her, and beat in her round-house: she did not over-set, but helpt some hundreds in saving their lives."

The shocks of earthquake continued, but with decreasing violence, for a period of nearly three weeks, and the survivors of the catastrophe at Port Royal fled to the plain of the Liguanea and encamped where the city of Kingston now stands. Here they were attacked by a pestilence, occasioned by exposure, scarcity of food, and the effluvium from the corpses which were floating up and down all over the harbor. Jamaica historians tell us that this epidemic "slew thousands of the survivors," but as they have limited the population of Port Royal to thirty-five hundred, and sixteen hundred of these perished in the earthquake, there were no thousands left to be slain. From a letter, dated Jamaica, September 20, 1692, it appears that about five hundred died.

Other portions of the island were more sensibly affected by the shock than was even Port Royal, and it is said that the elevation of the entire surface was considerably diminished. More houses were left standing in Port Royal than in all the rest of

the island put together, for scarcely a planter's house or sugar-works withstood the shock anywhere. Not one house remained standing in the village of Passage Fort, one only in the Liguanea, and none in Spanish Town but a few low and substantial structures that had been built by the Spaniards. From the Saltpond Hill, opposite Port Royal, water rushed out from some twenty or thirty openings, twenty feet above the sea-level, and continued running abundantly for two days. Vast land-slips stripped the mountain-sides of their forest, and left bald and bare scarps several miles in extent. Rivers were choked up and driven into new channels, and the entire appearance of the Blue Mountain Range was changed.

As far as Port Royal was concerned, the earthquake had reduced it to a cay of about the same dimensions as it presented in 1635 when Colonel Jackson visited Jamaica, and the work of fifty-seven years had been undone in one or two minutes. Although Port Royal is now again connected with the Palisades, the process of silting up does not appear to have proceeded so rapidly after the earthquake as it did before. In 1698 there was still a navigable channel over the ruins, for on the 8th of November of that year a committee of the House of Assembly reported: "That it is necessary to have a close fort of about sixteen guns erected upon the easternmost part of Port Royal, where the old church and King's House stood, which will not only secure the passage which the late dreadful earthquake made on that part of the town, but very much annoy any ship that may break into the harbour." As late as 1783—that is, ninety-one years after the earthquake—Port Royal is referred to in official documents as a "cay."

Sixty years ago the ruins of the submerged town were said to have been plainly visible in calm weather, and at the present day irregular masses of masonry can be discerned near the conical red buoy which marks the spot where the church stood. The popular belief, derived from the works of old authors, such as Martin's British Colonies, was that incalculable wealth was to be found among the ruins; for, according to these writers, "the wharves were laden with the richest merchandise, and the markets and stores displayed the glittering spoils of Mexico and Peru," at the time that the earthquake occurred. This, no doubt, was only meant for fine writing, as we know very well that the wealth and glory of Port Royal had departed some fifteen years before the catastrophe; but it served to inflame the public imagination, and in 1861 an American diver requested aid from the Government to explore the remains of the old city, offering to divide the treasure he might find. One trial was allowed him. He stated, on coming to the surface, that he had entered what was apparently a blacksmith's shop, and that he had found the remains of a fort,

presumably Fort Carlisle, but that he had been unable to enter it, it being entirely overgrown with coral, which had imbedded the guns in the embrasures as firmly as if they had been fixed in solid masonry. It was probably at this time that one of the bells of the old church, which is now in the Museum of the Jamaica Institute, was recovered.

At Green Bay, opposite Port Royal, concealed in dense bush, is the tomb of Lewis Galdy, a member of the Assembly of Port Royal, who fell into one of the crater-like pits caused by the subsidence of the sand, and was washed out again by the water gushing up from beneath. The inscription, which is rapidly becoming illegible, is as follows: "Here lies the body of Lewis Galdy, Esquire, who departed this life at Port Royal, the 22d of December, 1736, aged eighty years. He was born at Montpellier, in France, but left that country for his religion, and came to settle in this island; where he was swallowed up in the great earthquake in the year 1692; and, by the Providence of God, was, by another shock, thrown into the sea, and miraculously saved by swimming, until a boat took him up. He lived many years after in great reputation, beloved by all who knew him, and much lamented at his death."

As we have said, owing to the action of the tides and currents, the sand has again accumulated round the nucleus of rock at Port Royal, which presents, physically, much the same appearance as it did before the earthquake; and, notwithstanding the lesson of the past, the surface is again crowded with buildings. But what has happened once may at any time happen again; shocks of earthquake frequently occur in Jamaica, and it only requires one of sufficient violence to bring upon the new town the fate which overtook the old. Let us hope, however, that it will not occur.

Among the marked characteristics of the Melanesians, as described in Dr. R. H. Codrington's book about them, is the universal prevalence of secret societies, like the Duk-duk of New Britain, the Matambala of Florida Island, the Quatu of the New Hebrides, and the Tamate of the Banks Islands, which celebrated certain mysteries and peculiar dances, kept secret from the uninitiated and from women and girls, but having nothing religious, obscene, or idolatrous about them. The Banks Islands are considered by Dr. Codrington the chief seat of these societies, which are there called "The Ghosts." All these Tamate associations have as their particular badge a leaf or flower. The lodge or secret resort of the Tamate is the *salagoro*, established in some secluded place, generally amid lofty trees, in the neighborhood of every considerable village or group of villages. The whole place is set apart, not sacred, by sufficient authority, and no woman or uninitiated person would think of approaching it; yet foreigners are admitted without difficulty. These Tamate have survived the introduction of Christianity. All belief in the supernatural character of the associations has long since disappeared, but the societies occupied so important a place in the social arrangements of the people that they have held their ground as clubs.

RAPID TRANSIT.

LESSONS FROM THE CENSUS. VI.

By CARROLL D. WRIGHT, A.M.,
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WE have seen that the population of cities is rapidly gaining in proportion to the increase of population in the whole country, and also that this growth in cities is largely suburban in its character. The suburban growth is fed from without and from within. As business is extended, and the room and area formerly occupied by people are taken for great mercantile houses and for manufacturing, the population of such areas is sent out to the suburbs of necessity, while many seek suburban residences as a matter of choice. From without the suburban population is augmented by the rush to cities from the country. Owing to the improvement in methods of agriculture, by which production from the earth becomes in some sense a manufacture, a less number of persons is required for agricultural purposes than of old. The question is often asked why, if population increases, there is not an increasing necessity of supplying food products; and if there is such a necessity, why can great numbers be spared from the rural districts to engage in the business undertakings of the cities? Improved methods of production offer an answer to this question, the result being that the labor of the country not being in so great demand, even to supply the vast increase required in food products, seeks remunerative employment in centers of population. As the contraction of labor through invention goes on, the expansion of labor through invention grows to a greater extent; and it is probably true that through inventions, or through great industries which have come into being in recent years, a larger number of people are employed relatively than are deprived of employment through improved methods. The great industries associated with electrics, railroad enterprises, the building of new kinds of machinery, and the absorbing in various ways of laborers in occupations not known until within a few years, enables manufacturing centers to furnish gainful work to those coming from the country, where, relatively speaking, they are not needed. These people take up their residence in the suburbs, though they may find their occupations in the crowded areas of the cities themselves. The question of rapid transit in cities, therefore, becomes one not only of great interest in the study of the movement of population at the present time, but one of prime necessity for the consideration of municipal governments. It is something more than a question of economics or of business convenience; it is a social and an ethical question as well.

The bulletins of the census furnish, to some extent, the statistics relating to rapid transit in cities, and of the relative economy of different motive powers used on street railways. These bulletins have been prepared by Mr. Charles H. Cooley, special agent for rapid transit facilities in cities, under the immediate direction of that skillful statistician and economist, Mr. Henry C. Adams, special agent for transportation, and from them we learn the growth of rapid transit facilities during the ten years from 1880 to 1889, inclusive, in cities having over fifty thousand inhabitants. The special experts have selected cities on a basis of an estimate of population made at the time the compilation of the tables was begun.

The full reports of the statistics of the equipment of all roads furnishing rapid transit facilities, and of their operations for the single fiscal year ending 1890, are being collected, and the census authorities will present them in future exhibits.

Prof. Adams announces, and with truth, that street railways have never before been brought within the scope of the census statistics of transportation, and he points out the peculiar difficulties which were met with in collecting the facts already presented. Some of these difficulties arose from the ambiguity of designation, as "length of line," "length of single track," and "length of double track," when applied to street railways; and on account of such ambiguities the attempt has been made to fix upon some definite nomenclature by which careful returns can be secured. The conclusion is, that "length of line" means length of road-bed, or, in case of railways running entirely upon streets, the length of street occupied; that "length of single track" means the length of that portion of the road-bed or street laid with one track only; and that "length of double track" means the length of that portion of the road-bed or street laid with two tracks. In determining the total length of tracks, switches and sidings have been included, and thus double track has been reckoned as two tracks.

On December 31, 1889, 476 cities and towns in the United States possessed rapid transit facilities, the total number of railways in independent operation being 807. Many railroads, however (and the number is stated at 286, having a total length of 3,150·93 miles, and 13, having a total length of 135·75 miles), have as yet made no report; while in six the returns received were so imperfect that it was necessary to supplement them by approximations. This statement accounts for the bulletins not presenting statistics for a series of years for the whole number of railroads in the country, and 56 cities have been selected for which the reports are comparatively complete. Suburban lines tributary to large cities, but without their corporate limits, as well as

those actually within the cities, are included in the statement; as, for instance, where cities situated close together have a common street-railway system, it has not been thought best by the experts to attempt a separation in the tables. Therefore, Pittsburg and Allegheny, in Pennsylvania, are treated as one city, as are also Newark and Elizabeth, in New Jersey. The street-railway lines comprehended in Boston traverse also Lynn, Cambridge, and other suburban places.

The aggregate mileage of the fifty-six cities selected for each year from 1880 to 1889, with the increase and percentage of increase, is shown in the following table:

Year.	Total mileage.	Increase.	
		Miles.	Per cent.
1880	1,689·54	.....	.....
1881	1,765·95	76·41	4·52
1882	1,875·10	109·15	6·18
1883	1,941·49	66·39	3·54
1884	2,031·84	90·35	4·65
1885	2,149·66	117·82	5·80
1886	2,289·91	140·25	6·52
1887	2,597·16	307·25	13·42
1888	2,854·94	257·78	9·93
1889	3,150·93	295·99	10·37
Total	.....	1,461·39	86·50

It is only fair to state that in order to make the foregoing statement, the statistics of some of the cities have been re-enforced by information from sources other than the census returns.

By the above table it will be seen that from 1,689·54, total mileage in the fifty-six cities selected in 1880, the growth has been to 3,150·93 miles in 1889. This is an increase of 1,461·39 miles, or 86·50 per cent. These figures show conclusively the rapidly increasing wants of cities.

The five leading cities of the country have a mileage assigned them as follows: Philadelphia, 283·47; Boston, 200·86; Chicago, 184·78; New York, 177·10; Brooklyn, 164·44. These are figures for 1889, and they show the total length of line; but the total length of all tracks, including sidings, for the same cities, is as follows: New York, 368·62; Chicago, 365·50; Boston, 329·47; Brooklyn, 324·63; Philadelphia, 324·21. From these figures we find that the position of Philadelphia in the last statement is reversed, and that New York steps from the fourth place in the five cities named to the first place; and this brings out a peculiarity of the Philadelphia roads and, to some extent, the roads of Boston, the tracks in these cities, to a large extent, occupying different streets in going to and from a terminus instead of being laid upon the same street.

The motive power used on the total mileage given is divided as follows:

Motive Power.	Miles.	Per cent.
Animal power	2,351·10	74·62
Electricity	260·36	8·26
Cable	255·87	8·12
Steam (elevated roads)	61·79	1·96
Steam (surface roads)	221·81	7·04
Total	3,150·93	100·00

The relative economy of cable, electric, and animal motive power has been brought out by the census officers, but the superintendent remarks, in issuing the bulletins on this subject, that it is still too early to form a final judgment regarding the value of electric motive power for street railways; yet he feels that the statistics presented, being, as they are, a record of actual experience, throw considerable light upon the matter of economy. The lack of uniform accounts of railways prevents the use of the data already collected for the formation of a final judgment; while, again, the electric railways, being nearly all new, have not been in operation a sufficient length of time to afford final conclusions as to economy of service; and, as Prof. Adams points out, most electric railways are the successors of roads operated by horses, the horses being still retained on a part of the lines and the expense incurred for horse power being intermixed with that incurred for electric power. For these reasons a final judgment on the figures given must not be reached; yet the facts presented are indicative of what may be expected.

The bulletin relating to the relative economy of different motive powers embraces fifty lines of street railway, ten of which are operated by cable, ten by electricity, and thirty by animal power; and from the various tables presented, showing length, steepest grade, number of cars, car mileage, number of passengers carried, operating expenses, etc., a crystallized statement (which statement, it should be remembered, is not a complete and accurate one) is drawn, showing that the operating expense per car mile of cable railways is 14·12 cents; of electric railways, 13·21 cents; and of animal power, 18·16 cents; while the operating expense per passenger carried is, for cable railways, 3·22 cents; for electric railways, 3·82 cents; and for railways operated by animal power, 3·67 cents. It will surprise many to learn that in operation both cable and electric railways show a greater economy than railways operated by animal power; but in the full tables given in the bulletins it is noticeable that electric railways which have the least expense per car mile have the greatest expense per passenger carried. So the statement of the ratio be-

tween passengers carried and car mileage becomes essential, and from this it appears that electric railways show a less number of passengers per car mile than either of the other classes, the number of passengers carried per car mile being, for cable railways, 4·38; for electric railways, 3·46; and for railways operated by animal power, 4·95. Thus the electric railways carry a less number of passengers per car mile than either of those operated by cable or by animal power. The assumption is made in the census report that this variation is explained by the fact that electric roads, being new, occupy lines over which the passenger traffic has been but partly developed.

The expense per car mile and per passenger, the cost of road and equipment, and the volume of passenger traffic are essential for a full understanding of the financial side of the question. From the statistics reported it is seen that the total cost of road and equipment per mile of line (meaning thereby street length) is, for cable railways, $350,324.40; for electric railways, $46,697.59; and for railways operated by animal power, $71,387.38; and the number of passengers carried per mile per year is, for cable railways, 1,355,965; for electric railways, 222,648; and for railways operated by animal power, 596,563. From these figures it appears to be true that cable railways attain their greatest efficiency where an extremely heavy traffic is to be handled, and that electric railways and those operated by animal power are used where the traffic is not so heavy, or is more generally diffused.

The operating expense per car mile is: For cable railways, 14·12 cents; for electric railways, 13·21 cents; for railways operated by animal power, 18·16 cents; and the operating expense per passenger carried is, for the different powers as named, respectively, 3·22 cents, 3·82 cents, and 3·67 cents; but, including interest charge per car mile at assumed rate of six per cent, the sum of operating expense and interest per car mile is: For cable railways, 20·91 cents; for electric railways, 17·56 cents; and for railways operated by animal power, 21·71 cents. These charges, both actual and estimated, show a somewhat greater expense for cable roads per car mile than for electric roads; but when the interest charge is considered on the basis of passengers carried, and added to the operating expense, the sum of operating expense and interest per passenger is as follows: For cable railways, 4·77 cents; for electric railways, 5·08 cents; for railways operated by animal power, 4·39 cents, showing a less cost for operating expense and interest charge per passenger for cable railways than for electric railways. In the first instance, the greater charge for cable railways is on account of the much greater cost and equipment per mile; while the greater number of passengers carried by cable railways per mile reduces the ratio of expense on the passenger basis.

It is to be hoped that the complete statistics relating to rapid transit in cities will enable the public to determine, with reasonable accuracy, the relative economy of the different powers used. This is a question which is vital to the interests of city and suburban communities, and which leads to the ethical consideration of the problem of rapid transit. That power must eventually be used by which passengers can be transported from their homes to their places of business and return at the least possible expense, and the greatest possible safety commensurate with high speed.

The necessity of living in sanitary localities, in moral and well-regulated communities, where children can have all the advantages of church and school, of light and air, becomes more and more evident as municipal governments undertake to solve the problems that are pressing upon them. If it be desirable to distribute the population of congested districts through country districts, means must be provided for safe, rapid, and cheap transit to the country districts; or, inversely, if it be desirable to build up the suburban areas, the people must be supplied with cheap and convenient means of reaching the localities within which they earn their living.

The reduction of fares, through improved means of rapid transit, however desirable, is really a minor question. It is probably true that by a slight reduction from a five-cent fare the head of a family engaged in mechanical labor, earning perhaps five or six hundred dollars per annum, might save enough to pay taxes, or to offset church and society assessments, or to furnish his family with boots and shoes, in any event extending his power *pro tanto* for the elevation of his family; but he does more than this when speed is taken into consideration. By the old methods of transit from suburbs to the heart of a city a working-man going into the city of Boston was practically obliged, while working ten hours at his usual occupation, to spend an hour on the horse-railway, when now, on one line, by the use of the electric car, he can go to and return from his place of work in half that time, thereby actually adding to his own time half an hour each day, practically reducing his working time from eleven hours to ten and a half hours without reduction of wages and without increased expense for transportation. The question of rapid transit, therefore, as seen by this simple illustration, becomes an ethical consideration; for if there is anything to be gained by adding to the time which men have at their disposal for their own purposes, for intercourse with their families, for social improvement, for everything for which leisure is supposed to be used, then the question of rapid transit is one of far greater importance than that of saving money either to the man who uses transportation or to the company that secures dividends upon its stock. I be-

lieve, therefore, that all the efforts that are being made to secure convenient and cheap rapid transit in great cities are those which should bring to their support the help of all men who are seeking the improvement of the condition of the masses.

Business extension in cities is crowding the street area. This area is precisely the same in old cities like Boston, New York, Philadelphia, etc., for the present population and business operations that existed a century ago. The crowding of streets with the transportation essential for the movement of goods increases with great rapidity, but when the crowding is augmented, perhaps doubled, by the presence of the means of transporting passengers, the difficulties involved are almost appalling. With every increase of population the companies having in charge transportation facilities must, in order to accommodate the public, add more cars and more animals—if animals are the motive power—and so rapidly add to the already crowded condition of streets. This process is one which attacks the health and the safety of the people. The presence of so many horses constantly moving through the streets is a very serious matter. The vitiation of the air by the presence of so many animals is alone a sufficient reason for their removal, while the clogged condition of the streets impedes business, whether carried on with teams or on foot, and involves the safety of life and limb. It is a positive necessity, therefore, from this point of view alone, that the problems connected with rapid transit should be speedily solved, and this feature demands the efforts and the support of sanitarians. With the removal of tracks from the surface, and with tunnels built in such a manner as to be free from the dampness of the old form of tunnel, as has been done in London, and to secure light and air and be easy of access, all the unsanitary conditions of street-railway traffic will be at once and forever removed; and if private capital can not be interested to a sufficient extent to undertake such measures, then municipal governments must see to it that the health of the community is not endangered by surface traffic. When this question is allied to the ethical one, and when one considers the advantages to be gained, first, through securing rapid transit from the crowded portions of cities to the suburbs, and, second, by removing rapid transit traffic from the surface to underground viaducts, the importance of the whole problem becomes clearly apparent, and not only the importance of the problem but the necessity of its solution.

The statistics given by the census officers seem to indicate that as a matter of economy the very best equipment can be used without increasing the tax upon individual passengers. If underground roads can be used without at first increasing such tax, and still offer a reasonable compensation for capital invested, the

gains to the people at large offer an inducement to capital, while the many considerations of health and morals offer men who desire to use their means for the benefit of their kind an opportunity that has not existed in the past. From my knowledge of some of the men who have been foremost in projecting lines of rapid transit, but who have been accused of doing it for entirely selfish motives, I learn that public benevolence has influenced them to a sufficient extent to induce them to take the great risks which are apparently involved. I believe that could the real, underlying patriotism of such men be known, and the confidence of the public in their willingness to do work for the public benefit gained, the solution of the rapid transit problem would be much easier.

Capital is securing less and less margin of profit through its investments, whether in manufacturing or in other enterprises. The capitalist is satisfied with a safe and sure return of from three to five per cent, and the spirit of altruism, which seems to be growing more and more rapidly among our millionaires, and which is leading them to the establishment of great institutions for public good, will lead them ultimately to such operations as those essential to secure the best results of rapid transit. Private capital, encouraged and protected by public sentiment and municipal enactments, may be capable of solving this problem. If it is not, then public sentiment, interested in the welfare of the people at large, not only from an economic point of view, but from sanitary and ethical considerations, will insist upon a public solution of the question. It is an important study, and the officers of the eleventh census are entitled to great credit for their efforts to bring out the partial results they have published, and, later, to give to the country the full data relative to rapid transit in cities.

In a paper on the Meteorological Results of the Challenger Expedition in relation to Physical Geography, Mr. Alexander Buchan expresses the conclusion that the isobaric maps show in the clearest and most conclusive manner that the distribution of the pressure of the earth's atmosphere is determined by the geographical distribution of land and water, in their varying relation to the heat of the sun through the months of the year; and since the relative pressure determines the direction and force of the prevailing winds, and these, in their turn, the temperature, moisture, and rainfall, and in a very great degree the surface currents of the ocean, it is evident that there is here a principle applicable, not merely to the present state of the earth, but also to different distributions of land and water in past times. In truth, it is only by the aid of this principle that any rational attempt, based on causes having a purely terrestrial origin, can be made toward the explanation of those glacial and warm geological epochs through which the climates of northern countries have passed. Hence the geologist must familiarize himself with the nature of these climatic changes, which necessarily result from different distributions of land and water, especially those changes which influence most powerfully the life of the globe.

ORCHESTRAL MUSICAL INSTRUMENTS.

By DANIEL SPILLANE.

THE DEVELOPMENT OF AMERICAN INDUSTRIES SINCE COLUMBUS. XIV.

THE most profound and intellectual works of the great masters in the symphony and other forms of "instrumental" music—as they are classified in musical nomenclature—are interpreted through the orchestra, and through forms partly dramatic and vocal, such as opera and oratorio, in which the orchestra and various combinations of orchestral instruments play an important and inseparable part. Orchestral music is also an indispensable auxiliary to the proper representation of melodrama and in other departments of dramatic art.

Within the past forty years, especially since the close of the civil war, the progress of music in America has been most remarkable. This is manifest to-day in the large number of fine orchestras, musical societies and bodies throughout the country, and in the intelligent and generous support given to representations of the best class of music. A great demand has in consequence grown up for instruments for orchestral and band purposes. Many of these—for instance, the harp, violin, flute, violoncello, and cornet—being also largely used for private amusement at home and in small musical circles, their production gives employment to a large number of skilled workmen, and maintains a comparatively new and expanding American industry.

Though bands do not serve the high artistic purposes of orchestras—some full military bands, such as Gilmore's, Cappa's, and Sousa's, may be excepted—they fill an acknowledged place in the domain of the art. Bands have been associated with popular demonstrations since the earliest times, though originally in crude forms. In the illustrations of ancient Assyrian and Egyptian sculptures, given in the February issue in relation to the article on the piano-forte in this series, may be seen the precursors of modern band musicians marching in procession with lyres, dulcimers, harps, double flutes, and pulsatile instruments to commemorate some notable event, which indicates the fact that the human instinct which finds its expression in the maintenance of bands at this date is as old as the most remote chapter in the history of civilization. As compared with our instruments of music, however, these products of the Assyrians, Egyptians, and other nations of the far-away past were little more than toys. This remark applies equally to the instruments in use among the Greeks and Romans of a more recent period.

I fancy that Plato, Aristotle, and other philosophers of those

times must have had a fashion of drawing largely upon their imagination, or else some elements of human nature must have changed since then, for they all remarked the influence of music upon the manners of a people. If the crude musical system they were acquainted with, with its primitive instruments, was capable of such effects as they claimed, an interesting proposition is suggested for some student to elaborate—namely, are the people of the present less sensitive and less open to the influence of music—though having an incomparably superior system—than the ancients? This remains for some speculative and subtle mind to determine. Lyres, cithares, and incidental stringed instruments of that order have meanwhile become obsolete, while the dulcimer has no place in art. The harp has, however, come down to us through the centuries in an enlarged and vastly improved form as the most honored and most historic of all musical instruments. It is not so important, indeed, as the piano and parlor organ, and consequently could not have been treated in our previous articles with consistency, although it was a precursor, in its primitive forms, of the piano-forte and entitled to mention.

FIG. 1.—MODERN DOUBLE-PEDAL HARP.

The harp in its present form is capable of fine artistic effects, and is in most respects far different from the rude instrument of that species known in remote centuries. There are many kinds of harps produced, namely, the Welsh harp, which contains three rows of strings; the double harp, having two rows; the single-action pedal instrument and the double-action pedal harp, with one set—the latter being the most successful and artistic instrument of all. In fact, the single- and double-action pedal harps are generally used in musical circles to the exclusion of the two former.

Among the races identified with the improvement of this ancient instrument the Celts are entitled to first mention, the Irish and Welsh being in particular associated with it in the pages of history and romance. It still occupies a place in the festivals of the latter nation. Owing to the use of gut strings, the tones produced are more mellow and sympathetic than those of the piano, but this one advantage can not compensate for the various other disadvantages on its side as compared with the piano; that is, for popular use. What is not the case with the piano, the performer must be able to string and tune the harp. It gets out of tune rapidly, while the method of playing it calls for considerable expertness in the performer, owing to the absence of finger-keys and other mechanical conditions familiar in the piano.

The harp only became worthy of a place in the orchestra toward the end of the last century, when Southwell, of Dublin, and Erard, of Paris, invented the modern pedal-action system. Hochbrucker and Volter, German makers, made some notable changes in its construction about 1730, but until the invention of the system referred to it was not acceptable to musicians of culture.

The name of Erard ranks first in Europe to-day, after the lapse of a century, among harp-makers, but there are several other manufacturers of note in Berlin, Paris, and London, who produce instruments of the first grade. The pedal-action system of Erard enables the performer to raise the pitch of each string two semitones mechanically, which facilitates execution and effect to a wonderful degree. Harps were made in this country as far back as 1790. In that year Charles Watts, of New York, exhibited instruments of his own construction, but they met with little demand. For over a half-century harp-makers have existed here in a few cities, but up to about fifteen years ago the instrument had a very limited circle of patrons. Brown and Buckwell are the

FIG. 2.—VIOLIN, AMATI MODEL.

most time-honored names of American harp manufacturers—names best known to persons interested in this artistic branch. Comparatively little in the way of radical inventions has been introduced into the instrument since Southwell's and Erard's improvements were adopted, but a gradual development has taken place, the present concert harp being capable of larger and more extended tones and art possibilities than those instruments used in past years. Many native artists, among whom Miss Maud Morgan and Miss Inez Caruzi may be mentioned, have already appeared in America, while in the leading conservatories throughout the country professors of the harp are also engaged, and this educational work is steadily widening the circle of its admirers and patrons. James F. Buckwell, of New York, has introduced some improvements in the instruments of his manufacture; these can not be very readily described, however. Lyon & Healy, of Chicago, have also begun the manufacture of harps containing many patented points of improvement. One of the chief points of originality in the Lyon & Healy harps is the adjustment of the pedal-rods. These work in solid metal bearings in the column, and are a remarkable improvement over ordinary methods. In these instruments many other original features in the action and parts are also evidenced, and these permit the performer to make the most perfect mechanical adjustment of the scales in the various pedal positions ever made possible in the harp. A comparison of American harps on the whole with foreign instruments will go to show that they are equal in every respect, if not superior in some details.

ORCHESTRAL AND BAND INSTRUMENTS.—The violin and instruments of that order rule in the orchestra. Although bow instruments somewhat similar were known long before Christ, the violin of the familiar shape only came into use about the middle of the sixteenth century. One Baltazarini gave performances to wondering listeners in England in 1577, which is the earliest record known. The elder Amati began business in Cremona, Italy, in 1600, and is said to have founded that famous school. The Stradivari and Guarneri families subsequently appeared and bequeathed to the world instruments which are famous to-day. Germany, which claims to have first produced the violin, is represented by the names of Klotz and Steiner, who flourished during the same century. The violin became the leader in the orchestra, and still holds the foremost place there. The violoncello and other larger forms of the instrument were evolved between the middle of the sixteenth and the end of the seventeenth century, but nearly all effort has been concentrated on the violin, or "little viol," from which the familiar title came.

Dr. F. W. Adams, of Montpelier, Vermont, was perhaps the

most noted of early American makers. He was in the field in 1820. The first makers of instruments of the violin family were Benjamin Chrehore, of Milton, Mass., spoken of in connection with pianoforte-making, also Clement Claus, of New York, who came from London in 1790. Samuel Long, of Hanover, N. H., won considerable notoriety from 1812 to 1825 in that field; while Abraham Prescott, of Concord, N. H., took the place of the latter and became equally esteemed. Among the most famous were Warren A. White, of Boston, and Calvin Baker, of Weymouth, Mass., both more recent makers than Long and Prescott. Nearly all the violins turned out by those domestic violin-makers mentioned went among amateurs and into unpretentious orchestral circles. The professional musicians had always a preference for old instruments, and these of necessity came from abroad.

But within the past thirty years American violins fully equal to the best European instruments of modern times have been produced, some of which will be ranked with the finest examples of the Cremona masters in future years. These have come from the workshops of the Gemunders. George Gemunder is a native of

FIG. 8.—IMPROVED FLUTE, BOEHM MODEL.

Germany, where he was born in 1816, but he has lived here since 1847, almost a half-century, and is the only American violin-maker that exhibited in the musical instrument department of the famous World's Fair in London in 1851. He learned the art of violin-making from his father, and at nineteen became a pupil of Voillaume, in Paris, where he stayed four years. He began business in Boston in 1847, and in 1851 removed to New York, where he has since been located. August Gemunder is equally a renowned maker, his instruments being in the hands of some of the leading soloists. He was also born in Germany, but has been here since early manhood. Lesser makers in various cities produce good violins, while nearly all manufacture violas, violoncellos, and basses as well.

The modern transverse flute, passing over its precursors, was invented in Germany in the seventeenth century; hence the term "German flute." It was first used by Handel in orchestral scores, and speedily achieved a leading place, although up to recent years a very imperfect instrument. In its present perfected state it is very satisfactory, and capable of producing excellent artistic effects. The piccolo, a smaller species, has also come into being, and is employed in conjunction with the other in orchestras and bands. The latter is capable of producing the sharpest and highest tones known in the compass of any instrument. The flageolet

is the ancient form of the flute—with some differences—and is also used very widely.

The flute was first made acceptable for artistic requirements by Theobold Boehm about 1834. Not only did this celebrated inventor contribute to the flute, but his system of key adjustment, fingering, and tube-boring materially assisted the further development of the clarionet and other wood wind-instruments. He was anticipated in this country, however, in many points by Edward Riley, one of the earliest American musical instrument makers of the century. Boehm was a native of Munich, Germany, where he had a shop devoted to the making of wood wind-instruments. Captain Gordon, a Swiss military officer of Scotch extraction, was the inventor of the Boehm system of fingering, but Boehm applied it practically with modifications in 1835, and thus earned the credit of being the inventor. He crossed to London in that year and introduced his instruments to musicians, meeting with great success. These were made with the cylindrical instead of the conical bore and created much attention. Their appearance led to a revolution in the methods of flute-making practiced up to that period. Boehm took out no patent, hence the general adoption of his method of boring and other particulars soon after their introduction. His system of fingering in itself, however, involved a radical departure which musicians and students were loath to take up at once, but it is now firmly established.

Common flutes without keys were made in America before the Revolution, but Riley was the first maker of standing to appear in the field. He had a factory in Franklin Square, New York, as early as 1810, where he produced wood wind-instruments of various kinds for orchestral and band purposes. The firm of Firth & Hall came into existence about 1817, and was devoted to the

FIG. 4.—CLARIONET, WITH IMPROVED SYSTEM OF FINGERING AND KEY CONSTRUCTION.

manufacture of wood wind-instruments and music-publishing. Thaddeus B. Firth, of Maspeth, Long Island, a grandson of John Firth, yet carries on flute-making as a special branch, in which he has won some distinction. Flutes, flageolets, and piccolos of excellent quality are manufactured by various makers in this country at present, in connection with clarionets and other wood wind-instruments.

The clarionet, which plays a most important part in the domain of musical art, is a product of Germany, where it was invented in

1690 by Denner, of Nuremberg. It resembles the oboe in the structure of the tube, but sound is produced in it by means of a single instead of a double reed. Like all the instruments treated, it was very imperfect up to thirty years ago. It occupies the place of the orchestral violin in reed—ordinarily called military—bands. Meanwhile, the clarionet was not an "invention" in the exact sense, owing to the fact that it had a predecessor of the oboe family known as the *schalmey* or *chalamean* (from calamus, a reed). J. C. Bach, son of the master, first introduced it to

FIG. 5.—THE BASSOON, AN IMPORTANT AUXILIARY IN ORCHESTRAS AND MILITARY BANDS.

notice in his opera of Orione, in 1760, and its general adoption followed. It was given a leading place, in military bands in particular, as a treble instrument from the moment of its inception. Within the past half-century larger forms of the instrument appeared—alto, tenor, barytone, and bass—for military band purposes, their artistic use being to soften the brasses and lend color to the *ensemble* and to special effects.

Saxophones are a production of this century, and indispensable in full reed or military bands. They are played with a clarionet mouth-piece, and resemble the clarionet, only that they are made of brass instead of wood. Saxophones are the invention of the celebrated Antoine Sax, of sax-horn and musical-instrument fame. While working in his father's shop, in Dinant, Belgium—in which city he was born in 1814—he conceived the idea of their construction. Settling in Paris in 1842, Sax won a leading place as a maker of wood and brass wind-instruments. He secured a patent for his saxophones in 1846, and in time introduced them into the French military bands, other nations acquiring them subsequently. They have been improved largely since their production, and, though not ranking high as solo instruments, they enjoy an important place in large bands as instruments essential to artistic aims in *ensemble*.

FIG. 6.—SAXOPHONE.

We arrive now at brass instruments, such as the horn and cornet, in which sound is produced by means of the lips vibrating in the mouth-piece. To readers acquainted with the common bugle the principle will be easily apparent. The origin of the

horn is lost in antiquity. It is the parent—in its native form without pistons—of the numerous family of piston and slide instruments which have been evolved within the past century, and it is one of the relics of the past, which has maintained a place in the modern orchestra or military band through the addition of valves. The instrument in question is known at present as the French horn, to distinguish it from the sax-horn and the

FIG. 7.—SLIDE TROMBONE.

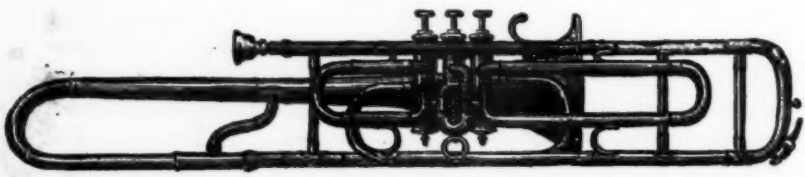

FIG. 8.—VALVED TROMBONE.

English horn. When Beethoven first wrote for it in the orchestra it was in its primitive state, the tones produced being those of the harmonics of the open tube. These are doubtless familiar to most readers who have heard military bugles. Intermediate tones were produced by the insertion of the hand in the bell of the instrument at first, which muffled the tone and so rendered the effect uneven in *timbre* and not acceptable for solo purposes. The introduction of pistons, about 1840, obviated the former drawbacks, but its normal tone-character renders it useful merely as an accessory, for it is too soft, subdued, and lacking in individuality to win a place as a solo instrument.

FIG. 9.—DUTY BUGLE, THE PRECURSOR OF THE CORNET.

The slide trombone and trumpet are equally ancient in their primitive shape. The former yet maintains a leading place. Besides the harmonics of the open tube referred to, intermediate semitones, so as to complete the range of the accepted octave, are easily produced in the trombone by means of the slide, which lengthens or decreases the tubing as required. Since valves were invented, they have been applied to the latter, but the slide trombone is yet preferred, owing to the superior purity of its tones,

which, however, hardly compensates for defectiveness in phrasing and other drawbacks.

Up to about 1840 the keyed or "Kent bugle" held the place now occupied by the cornet, although in being only since 1807. That now obsolete instrument was the familiar duty or field bugle, to which keys had been added so as to allow the production of intermediate tones in addition to the harmonics indicated.

Halliday, an Irish gentleman, who invented that instrument, discovered by accident that, by boring holes in an old field bugle, extra tones could be produced. Ellard, a musical instrument maker of Dublin, made him a model after some experiments, and the latter having added further improvements, it was submitted to the Duke of Kent, who introduced it into his band, whereupon it took the name of the "Kent bugle."

When the allied armies entered Paris after Waterloo, the Grand Duke Constantine of Russia heard the bugle for the first time. Through Distin—father of the modern family of that name—then soloist in the Coldstream Guards band, he secured a copy, and on returning to Russia had it adopted in all the imperial bands. It had a short existence, however, for within a few years the cornopean—as the cornet was at first named—succeeded it. This was not merely an incidental step beyond the Kent bugle, for it resulted in the production of a complete family of brass instruments within a few years, namely sax-horns, besides influencing the French horn, trombone, and trumpet, and art generally. It appeared first in Russia, but its invention was claimed by the elder Sax, and by a Mr. Adams, an American. The latter had no patent and never proved his right to the claim advanced, while the representations of Sax stand equally discredited. The real author is yet unknown. The chief features of originality in the cornopean or cornet over the keyed bugle consist in the use of three pistons, which, on being pressed singly, or in combination, shut off, or add, certain lengths of tubing, so as to raise or lower the pitch, these valves being perforated to assist that end.

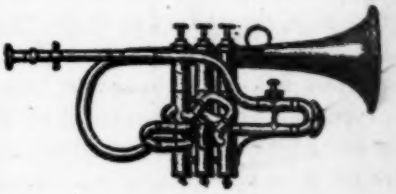

FIG. 10.—SOPRANO CORNET.

FIG. 11.—CORNET, SHOWING ROTARY VALVE SYSTEM.

Antoine Sax, of Paris—the greatest inventor of the age in that field—in addition to his feats in relation to the saxophone, took

the cornet in its crude state, regulated the tube lengths, cut away rough angles in the air-passages of the valves, and made it more acceptable for artistic needs. It became popular immediately, the great Koenig and other artists appearing before 1850 to give it notoriety. In 1846 Sax also introduced his sax-horns, from soprano to bass, which were adopted in all countries, with special improvements and modifications. The brass bands of modern character—called "cornet bands" in some parts of this country—therefore became a possibility. In sax-horns and more recent adaptations of these instruments, such as the circular basses and euphonium, the same piston system prevails as in the cornet.

Bands were chiefly used for military purposes up to about 1840, when amateur and professional organizations for public celebrations appeared.

FIG. 12.—TENOR SAX-HORN.

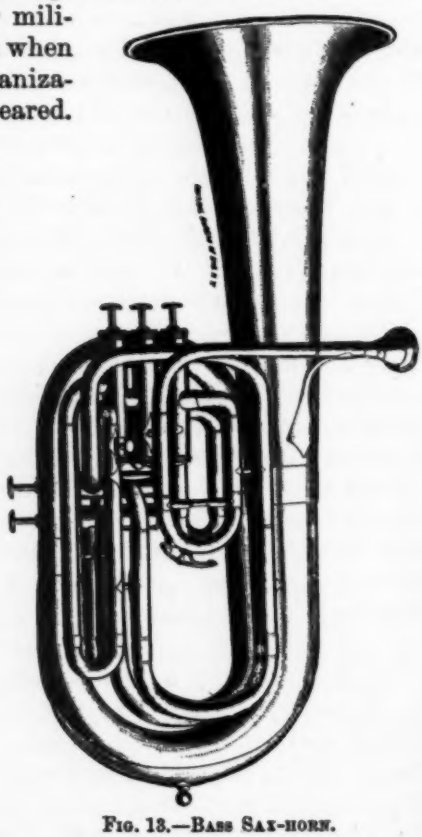

FIG. 13.—BASS SAX-HORN.

Previous to the appearance of the clarionet they were composed of hautboys, sackbuts, trumpets, flutes, serpents, horns, and various other obsolete instruments, all of a crude character, besides drums, cymbals, and pulsatile accessories. Yet the invention and adoption of sax-horns in military bands gave rise to an entirely new order of instrumentation in the abstract, but without disturbing the clarionet from the position it has always occupied.

The manufacture of brass wind-instruments in America was be-

gun about 1835, but the few bands then in the country constituted the market to be relied upon. American bands, and the spread of the cornet and other brass instruments among private parties which increased after the war period, helped to maintain a few small manufactories devoted to the cheaper variety, until about the great Centennial Exhibition year, when Henry Distin, son of John Distin spoken of above, removed from England and began to manufacture the justly celebrated "Distin" instruments in the United States. The Distins had been previously in business in London for a great many years, and had won a leading place in that sphere. Henry Distin's arrival here practically established that industry in this country.

A notable sign of the progress going forward in this art and industrial channel is the town of Elkhart, Indiana, the mainstay of which is a manufactory founded by C. G. Conn, devoted to military band instruments of a high order, which are fast winning a leading place. Mr. Conn established himself in business in 1883 upon an enlarged scale after being burned out; he had been only a few years in the field at the time. The Distin factory is situated in Williamsport, Pa. Several other smaller makers of the cheaper class of musical instruments are scattered throughout the country.

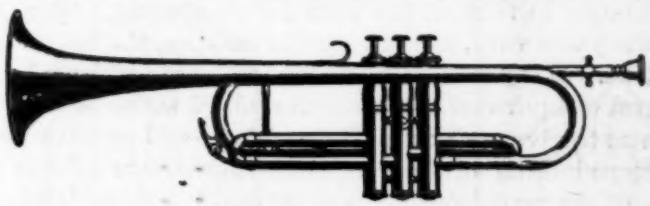

FIG. 14.—MODERN VALVED TRUMPET.

In addition to the branch treated, Lyon & Healy, of Chicago, Haynes & Co., of Boston, and Stratton & Co., of New York, maintain factories devoted to the production of guitars, mandolins, and small instruments of that order, which give employment to a large number of hands. These industries being of very recent growth, it is impossible to give any comparative estimate of their progress in the absence of the statistics for 1890, which has not yet appeared. The table for 1880 would in itself be no guide, for the above reason.

Meanwhile it is a source of satisfaction to know that such activity prevails in relation to musical art in America as the articles throughout indicate. It also shows that Americans, as a people, are wonderfully versatile, and capable of establishing industries which are maintained as specialties in countries abroad, while capable of improving almost everything which they undertake to manufacture. That has been distinctly shown in the music industries at least.

VARIATIONS IN CLIMATE.

By W. H. LARRABEE.

SPECULATIONS concerning changes of climate have an interest that never flags. It rarely happens in the succession of seasons that two of an identical character come in succession; and any more than usually marked variation easily prompts the fancy that some modification in the character of the climate is impending.

The subject of climatology is a difficult one. The data for the proper study of it have hardly begun to be collected. We are embarrassed when we undertake to define climate and what marks to accept as its characteristics. Hann and Humboldt define it as comprising the whole of the meteorological phenomena characterizing the state of the atmosphere at any place, particularly as they affect our organs or have an influence on animal or vegetable life. The general character of the conditions can not be determined by the observations of one year, for they are liable to be contradicted by those of the next year; nor by those of any short term of years, for a similar reason. A period must be taken long enough to furnish the data for composing a type; and the more the years vary, as between one another, the longer must the period be. Many factors enter into the composition of a climate and form complicated combinations, all of which must be unraveled so as to give each factor its true force and position; and then the determination of their relative importance affords another source of embarrassment. Temperature and moisture are accepted as the most important factors, and temperature as the dominant one; and the climate is deduced by considering the average mean temperature for a term of years. Equal yearly averages do not, however, signify identical climate. A place where the summer heat and the winter cold are extreme has not the same climate as one where the range is relatively narrow, though the yearly averages may be the same in both. Hence we need separate determinations of summer and winter averages. The combinations of conditions of temperature and moisture may be endless, while the averages of either may be hardly disturbed. These facts make it hard to compare climates even when they are steady for long periods. In the capricious climates of our temperate latitudes a just determination and comparison form a baffling task.

Observations, more or less systematic, with instruments, have been made of climatological features for about a hundred years, but on a general co-operative plan they have been carried on imperfectly for less than a third of that time, or about the period

within which some observers suppose a round of meteorological changes is accomplished for a single locality. Popular opinions are founded most largely on hap-hazard recollections of vague impressions that can not be depended upon; and even if we had accurate records in place of these, they could not be used to determine the trend of climate on account of the short time they cover. It has happened more than once during that time that a series of seasons of a peculiarly marked character has been followed abruptly by a series of opposite character, nullifying the conclusions that may have been taking shape from the former series. The speculations concerning a decrease of rainfall in the United States in consequence of the removal of the forests have been disturbed by the recent prevalence, in part of the disforested area, of a succession of seasons of heavy and continuous rains.

Cosmical revolutions and changes taking place on the surface of the earth have been mentioned as causes by which climates may be permanently modified, and have been brought in to account for the changes which geology shows have taken place in the past.

Among the theories of cosmical causes, one, which supposes the solar system to be carried through parts of space having different constitutions or different temperatures, may be dismissed as being purely hypothetical. No fact has been adduced in support of it, and no valid reason has been presented for supposing that there are differences in the parts of space. Other theories, which refer climatic changes to astronomical cycles affecting the earth's orbit and its position therein, have a more substantial basis. They have been considered by sober authors and have a hold on the minds of intelligent students; and the cycles have a real existence and are capable of producing effects that can be calculated. They comprise a secular variation in the obliquity of the ecliptic; the precession of the equinoxes, with the attendant revolution of the apsides; and an oscillation in the eccentricity of the earth's orbit—all conforming to regular and well-defined periods.

The variation in the obliquity of the ecliptic affects the distance to which the sun departs from the equinoctial at midsummer and midwinter. Its action is to heighten or reduce the contrast between those seasons according as its measure is greater or less. By precession the equinoctial points shift their places backward along the ecliptic, accomplishing a revolution in 21,500 years. It entails the revolution of the apsides, which is equivalent to a displacement in relation to the seasons of the points of the earth's greatest and of its least distance from the sun. By the variation in the eccentricity of the earth's orbit these distances, called the aphelion and perihelion distances, are lengthened and shortened, the difference between them is increased and diminished,

and the quantity of heat received from the sun by the earth in different parts of its orbit is supposed to be correspondingly modified. These differences are greatest when the eccentricity is greatest. If with this is combined such a position of the equinoxes that summer in one hemisphere shall correspond with the perihelion and winter with the aphelion, the contrast of the seasons in that hemisphere will be most marked, and we shall have the conditions, according to one theory, for a glacial period.

Such, according to M. Jean Reynaud, was the case in the northern hemisphere about 9500 B. C., when, he thinks, our last glacial period was at its height. From that time the differences were gradually reduced till about 1250 A. D., when they became least, and the northern seasons were mildest and most equable. The differences then began to enlarge again, and we are now advanced a little more than six hundred years toward another glacial period. According to this theory, the seasons were growing milder all through human history till 1250 A. D., and have been tending to become more severe since then.

A question of fact is here presented, evidence respecting which is sought, in the absence of exact observations, in such records as may happen to exist of the character of seasons in the past. M. Arago several years ago collected a considerable list of mentions in the literature and documents of former times of periods of unusual cold, of long or cold winters, unusually hard freezing of rivers, and remarkable heat, drought, or rain, which constitutes our principal source of information on the subject. Parts of this list have been used by M. Jules Peroche and M. Amadée Guillemin to establish opposite conclusions as to the validity of M. Reynaud's hypothesis.

Latin poets furnish some of these data, as when Ovid complains of the inclemency of his place of exile on the Black Sea, in what is now pleasant southern Russia; or Horace and his compeers describe terrible storms in Rome; or Juvenal tells of a Roman lady having to break the ice of the Tiber to wash her face. Cicero and some of the historians speak of the severe climates of Gaul and other outlying provinces, evidently contrasting them with the pleasures of life in Italy. The discomforts experienced by Hannibal in crossing the Alps were what an army from the south would suffer in any age in crossing those mountains in winter, if they were roadless and inhabited by barbarians. To a candid critic, these representations mean nothing on one side or the other, and such is the conclusion which M. Angot has reached after carefully examining the subject.

Of fifty-six instances of extreme winter severity cited by M. Peroche from M. Arago's list, fourteen occurred before the supposed "Great Summer" year, 1250. There seem to be more of

them as we approach the nineteenth century, but we have a right to assume that that is because the records are fuller near our times, not necessarily because extremes are growing more frequent or marked. None of the instances, ancient or modern, betoken greater severity than the frosts of 1234—sixteen years before the "Great Summer" year—when "the Po and Rhône were frozen, and loaded wagons crossed the Adriatic on the ice opposite Venice"; 1236, when "the Danube was frozen to the bottom for a considerable time"; or 1305, fifty-five years after it, when "the Rhône and all the rivers of France were frozen." With all the greater completeness and systematic organization of modern observations, the records of the nineteenth century contain no mention of such seasons as those of 1323, 1333, 1349, 1402, and 1407, when the southern part of the Baltic was frozen so hard that men could ride on horseback from Copenhagen to Lubeck and Dantsic.

These occasional winters of exceptional severity can not be taken as typical of the general character of the seasons, any more than we can characterize a winter by an extreme day in January, or a summer by an unusually sultry July day winding up in a thunder-shower. A surer guide to the habitual climate would be afforded by regarding the development of plant growth and the maturing of crops. Of these the vine has been taken as a type. It is said that, cultivated in the time of Julius Cæsar only in the southern parts of Gaul, or France, it was gradually carried northward to the fullest expansion in the thirteenth century, when there were vineyards and wine was made as far north as Flanders and England. Since then it has retired from the most northern points it had reached, where the grape is now ripened under glass. So the cultivation of the olive is said to be falling back toward the south; the sugar-cane has disappeared from Provence, where it once grew; less tender plants are taking the place of the orange in some quarters; and a depression of the zone of forest vegetation is mentioned as taking place in the Alps and the Carpathians.

There are many other causes than climate, as the present operations of agriculture and horticulture amply demonstrate, by which the cultivation of a crop in any place is determined. It may be found after some years of experiment to be unprofitable or of poor quality there; or may be supplanted by new and better varieties growing in more favored localities, or superseded by the introduction of new and more profitable products, which the cultivator is always ready to take up. Such causes have more force now than they ever had before, because of the great increase in the facilities for exchange under which it is no longer necessary to cultivate anything except in the places where it will do best. M. Angot has, moreover, found, by consulting the offi-

cial records of the times of the opening of the vintages as far back as to the fourteenth century, that there has been no real change. The times have varied in the same places, in different years or series of years, during all this period, as much as two months, but there has been no regular variation, or any of a character to support the hypothesis of a constant, secular movement.

M. Arago undertook, about fifty years ago, to measure the value of these cosmical influences on climate, and declared that they were not competent to produce an effect within the period of historical time worthy to be regarded. He found that the present effect upon the surface of the cooling of the earth's interior, which some were disposed to regard, could be comprised within a thirtieth of a degree. Sir William Thomson makes it still less, and limits it to one seventy-fifth of a degree. M. Arago saw no reason for supposing there were differences of temperature in the parts of space, while, if there were, they would affect all the earth alike and not one hemisphere more than another. The variation in the obliquity of the ecliptic, small in its total at the most, could not cause a change of more than a quarter of a degree in two thousand years.

M. Arago likewise depreciated the importance of the precession of the equinoxes and the variation in the eccentricity of the earth's orbit as climatological factors, because, as he showed, during a period of long eccentricity with summer at the perihelion, while the hemisphere may receive a more intense heat during the summer part of the revolution the excess is balanced by the season's being shorter; but the winter will under those conditions be both colder and longer. Sir John Herschel and M. Reynaud have answered him as to this point by saying that character is given to the season, not by the absolute quantity of heat received, but by its distribution; not its mean temperature but its maxima and mimima of temperature are to be considered, and the greater or less rapidity of the ascent and descent of thermic movements. A difference of four and a half times in eccentricity, such as is possible, might work great changes in these properties; so that in the case considered by M. Arago "half the annual heat would be concentrated into a summer of very short duration, while the other half would be distributed through a long and gloomy winter, made intolerable by the intensity of the cold, increasing in proportion to the distance of the sun." M. Arago thinks that it would take ten thousand years for variation in eccentricity to effect a change of temperature in the earth measurable by the thermometer. No evidence is produced that it has had any effect within the historical period.

Thus, whatever may be the importance of these astronomical causes in determining the climatic features of geological periods,

it is usually agreed that they may be disregarded in accounting for such changes as may have taken place within man's memory. Mr. James Croll, who has discussed this question with considerable fullness, and is inclined to allow them all the force they are entitled to, ascribes less importance to their direct operation than to the secondary effects they induce through their influence on the currents of the ocean and air and upon features of the earth's surface. M. Woeikoff allows them still less agency in the matter than Mr. Croll, and ascribes the greatest influence upon climate to the elevation and configuration of the land, as Mr. Lyell did in the earlier days of geology; and M. A. Blytt, of Christiania, has shown, by pertinent contemporaneous examples, how climate in Scandinavia may be influenced by slight differences in situation, soil, and exposure.

The whole subject has just been reviewed by Sir Robert S. Ball, Astronomer Royal of Ireland, one of the most eminent living mathematicians, in his book on The Cause of an Ice Age. Speaking particularly of Glacial periods, he shows that changes in the intensity of solar radiation, relatively unimportant to the sun, may produce enormous climatic effects on the earth. By an exact calculation he finds that, with the present obliquity of the ecliptic, while the earth as a whole receives equal amounts of heat from the sun during the two halves of the year, the distribution as to a single hemisphere is extremely unequal—a fact which previous writers seem to have overlooked—the exact distribution being sixty-three per cent of the whole amount of heat during the summer and thirty-seven per cent during the winter half. When the line of the equinoxes is perpendicular to the major axis of the earth's orbit and the eccentricity is at its maximum—the conditions establishing the greatest possible difference in the length of the seasons—the sixty-three per cent of heat is distributed over a very short and therefore intense summer, and the thirty-seven per cent over a long and therefore cold winter. The northern hemisphere, when placed in such a condition, will have a summer of one hundred and sixty-six days, during which the sun is at its least possible distance, and a winter of one hundred and ninety-nine days, with the sun at its greatest possible distance. This Prof. Ball regards as a condition favorable to glaciation. The ice and snow will accumulate during the rigors of the long winter, while the succeeding brief summer has not power enough to thaw as much water as has been solidified in the winter, and the ice will grow from year to year. All this time the southern hemisphere would be enjoying a widely different condition. Its summer would contain as great a number of days as it is possible for that season to possess, while the fierce heat of the sun would be abated from its average amount, because the sun would be at

the greatest distance from the earth it is possible for it to attain. The winter would be short and warm. The present difference in the length of the seasons is seven days, and the position of the perihelion is such that it is near its maximum for the present eccentricity. The directions in which the precession of the equinoxes and the variation of the obliquity of the ecliptic are tending are for reduction of the inequality, and ice ages are not to be expected from vicissitudes such as are now possible.

It is not denied that climates have been, and are, changing; but the changes are believed to be special, local, temporary, and oscillatory, and most largely determined by causes that may be found on the surface of the earth. M. Arago thought they might all be attributed to agricultural works, to the clearing of woods from plains and mountains, to the drying up of marshes; and he doubted if it could be proved that the climate had become warmer or colder in any place the physical aspect of which had not been perceptibly changed during a series of ages.

The present drift of the opinion of many careful students of the subject seems to be that exaggerated ideas have been held of the extent of climatic variations, both in the present and the past. M. Woeikoff, whose opportunities for studying climatological phenomena over a large extent of territory have not been surpassed, believes that this is so, even when the application is made to the Glacial period; that not intense cold, but those conditions of temperature and moisture most conducive to the precipitation and accumulation of snow, formed the chief factors of its characteristic phenomena. Chief among these were proximity of the sea and a temperature of the surface-water rather below than above the freezing-point. The effect on glacial accumulation of the conditions commonly supposed to correspond with the combination of high eccentricity and an aphelion winter would, in his opinion, be the opposite to what is attributed to it; for the greater cold assumed to prevail in winter would not be conducive to the precipitation of snow, while the more intense heat of midsummer would probably melt the snow at heights where the present temperature rises but little above the melting-point. Hence the conditions in the interior and eastern part of a continent like Asia would be less favorable than they are now to marked glaciation. The western parts of continents and islands would be more fully under the influence of the sea; and as there is no reason to suppose that its surface temperature would be lower than now, it follows that there would not, all other things being equal, be more snow than now in countries where rain is the rule, even in winter. The effect of the combination would be in any case but slight, and not by far, in M. Woeikoff's opinion, to be compared

to that of such geographical conditions as the distribution of land and sea, and of mountains and lowlands.

The idea that glaciation was dependent on extreme cold has been rejected by other students. J. de Charpentier recognized the conditions as inconsistent. Lecoq, of Clermont, "affirmed a correlation between a great solar heat, provoking a powerful evaporation, and the formation of glaciers." Tyndall has shown that the ice of the Alps "derives its origin from the heat of the sun," and that if that were diminished their source of supply would be cut off. The thoughts of some other writers, as Le Blanc, Forbes, and Charles Martins, have been turned to showing that the depression of temperature, if there was any, need not have been great.

Another group of writers, whose views have been summarized by M. Millot,* of Nancy, hold that warmer climates than now prevail were more favorable to glaciation, and gave character to the Glacial period; and that the present conditions of limited glaciation are the result of the sun's cooling, whereby the supply of evaporated moisture has fallen off. They claim that their theory furnishes the simplest explanation of the presence of warmth-loving plants and animals along with evidences of ice-action. The hot and the glaciated region were so close to one another that the mixture easily took place.

Prof. G. F. Becker, of the United States Geological Survey, has also expressed the opinion (Popular Science Monthly, February, 1884) that the Glacial period was one of higher mean temperature at the sea-level than the present; that while the formation of glaciers may have been affected by all contemporaneous changes, including secular revolutions, it is not necessary to have recourse to such causes; the question is chiefly one of differences between the temperatures at the sea-level and those at the level where the glacier was formed.

M. Blytt, studying the distribution of the Scandinavian fauna, has found it subject to considerable local variations at short distance, which have relation to differences in conditions of exposure and the character of the soil. He concludes that no great changes, but only small variations in the extremes of temperature and rainfall, are required to explain these departures. Such variations may be produced, for his country, by fluctuations in the direction, force, and temperature of ocean currents and winds that need in no case be great; but he believes that these variations are coincident with periodical changes of climate corresponding with secular incidents.

The considerable effects of exposure on local climates are

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* Popular Science Monthly, August, 1885.

exemplified at the winter seaside resorts on the south coast of England, where certain spots enjoying conditions of shelter from cold winds, combined with exposures favoring the concentration of the sun's rays and the warm winds upon them, enjoy a spring-like mildness through much of the winter. Prof. W. Mattieu Williams* speaks of Torbay, Torquay, Broadstairs, and Hastings as possessing these characteristics. A considerable difference has been noticed in the winter temperatures of places east and west of a certain point on the coast, though all are nearly in the same latitude.

Dr. D. Hart Merriam has described a succession of temperature zones in descending from the plateau level to the bottom of the Colorado Cañon equivalent to those stretching from the coniferous forests of northern Canada to the cactus plains of Mexico, with marked variations of climatic conditions under apparently very slight diversities of exposure.

A variation of only 5·3° Fahr. in the mean annual temperature at Uskfield, England, is shown by Mr. C. Leeson Prince† to be sufficient to exert an enormous influence on the general character of the seasons, the produce of the soil, and the health of the population.

The fact of changes in climate being admitted, discussion turns upon their extent, and the laws by which they are governed. In many cases they are brought about by changes in local conditions, of which the removal or replacement of forests, or the relations of land and water, are among the most important. In other cases a periodical law is supposed. The attempt has been made by some meteorologists and astronomers to show that there is a connection between such changes and an eleven-year period of abundance and scarcity of sun-spots. It was believed by an observer in Ceylon in 1872‡ that that island was on the eve of an important change of climate depending upon a cycle of thirty or thirty-five years. The previous thirty years, he asserted, had shown a complete contrast to the thirty years preceding them, with manifestly different effects on animal and vegetable life. It had been a period of relatively lighter rainfall, and the next cycle of thirty years was expected to be, above the average, wet. This theory of changes by thirty or thirty-six years is often met in following the discussions on this subject. A paper published recently in the *Archives des Sciences Physiques et Naturelles*# deduced from a total of twenty thousand years of observations, at about five hundred stations, that the climates of all the continents, excepting only a few maritime coast regions, were subject to simultaneous varia-

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* Popular Science Monthly, March, 1886.

† Nature, vol. xx, p. 419.

‡ Nature, vol. v, p. 412.

Ciel et Terre, January 16, 1889.

tions, which became more and more pronounced toward the interior regions. The years 1815, 1850, and 1881 came about the middle of relatively wet periods, and 1830 and 1860 of dry periods. The mean period of the oscillations was deduced from records of vintages, going back to the year 1400, to be thirty-six years. The changes appeared to be dependent on certain relations of atmospheric pressure, the wet periods being characterized by lesser differences, and the dry periods by increased differences, in that factor. The theory of a period of thirty-five or thirty-six years is fully elaborated by Prof. E. Brückner, of the University of Basle, in his book *Klimaschwankungen* (Vienna and Olmutz, 1890). Approaching the question from nearly every conceivable point of view—of temperature, precipitation, atmospheric pressure, the rise and fall and freezing and thawing of rivers, vintages and harvests—he is led to the same conclusion in every case. The period is nearly equivalent to three of the supposed eleven-year sun-spot periods. Herr G. Hellman has counted thirty-four seasons since 1755 when December and January in Berlin were warmer than the average; but the warm seasons came at irregular intervals, and did not suggest any law.

Dr. W. Koppen, of Hamburg, records, as the outcome of an investigation which he made of the periodicity of weather-changes, "that for certain intervals strongly marked periodical influences make their appearance and then vanish entirely, at times being replaced by others of a totally different character. No law has, as yet, been discovered for these changes."

The presence of forests has not been shown to contribute directly to the increase of rainfall, nor their removal to diminish it. Yet their influence on climate must be considerable. This is confessed when the farmer on the prairies plants belts of trees between his fields and the quarters from which cold winds and destructive storms are expected. They stand like a wall to protect the localities they overhang against sudden extremes of temperature and other accidents of violent weather. Although they may not increase the amount of precipitation to a perceptible extent, they, by means of their matted roots and the undergrowth which they promote, and by their beneficent shade, convert the ground on which they stand into a kind of reservoir, and husband the moisture which, without them, would run off or dry up at once. Thus they contribute to prevent sudden floods in the wet season, and, permitting a slow exudation of moisture into the streams, to keep them lively and the rivers to which they are tributary full during dry seasons. Many persons believe, too, that they diffuse a coolness and vaporous moisture in the atmosphere, the presence and influence of which, although they are not manifested in rain, are nevertheless real. Whether they may

not exert an influence on the distribution of rain through the seasons, as they certainly do on that of ground moisture, does not appear to have been yet adequately investigated.

In connection with the influence upon climate of the relations of land and water, the speculations respecting the probable effect upon the climate of Europe of flooding the Desert of Sahara deserve to be noticed. It has usually been taken for granted that a cooler condition would follow. But Prof. Hennessey argued several years ago that, as vapor, rather than dry air, is the chief vehicle of wind-borne heat, the result would be the opposite of this. While the midday heats of the desert are intense, the nights are cold. Hence a uniformly warm breeze can not come from there. The warm southwest winds of central and southern Europe have been found to be connected with the currents of the Atlantic, and not to come from the desert. The substitution of water for barren sands and rocks would be followed by the storing up of the heat of the sun which is now partly dissipated by radiation at night, and would furnish a source of constant warmth.

BAD AIR AND BAD HEALTH.

By HAROLD WAGER and AUBERON HERBERT.

THE purpose of this paper is to utter a warning against the careless way in which the great mass of people, poor and rich, ignorant and learned, allow the air of their living-rooms to be in an impure condition, and to point out the great sacrifice of energy and health which results from this carelessness. We shall try to show that there is strong ground for believing that not only a large part of the ever-increasing trouble of bronchial and lung affections, but also a very large part of that vague and subtle ill-health which troubles our modern lives in varying forms, is to be placed to the account of the impure air which we so habitually breathe.

As we wish to make the paper plain to every one, we shall occasionally go back to the A B C of certain matters involved. The air which we breathe is made up of two gases, one active, one indifferent. The active gas, oxygen, on which life depends, is in the proportion of about one fifth (twenty-one per cent) of the whole; the indifferent gas, nitrogen, which tempers and dilutes its active partner, is in the proportion of four fifths (seventy-nine per cent), and with these two gases is found a small quantity—varying according to the purity of the air—of carbonic acid, about three to four parts in 10,000 parts, or 0·04 per cent, and in addition a minute quantity of a peculiarly active form of oxygen,

called ozone, which is rarely found in the air of towns. Of this gas-mixture (which we call air) we breathe enormous quantities. Of it we breathe in the twenty-four hours, according to Prof. M. Foster, over 2,600 gallons, that is about 425 cubic feet; and as it returns from our lungs the proportions of the mixture are changed, the oxygen being reduced, and the carbonic acid increased.* But in all ordinary cases the quantity of oxygen in a room in which people are meeting is only slightly decreased, while the increase of the carbonic acid is not sufficient to cause bad effects. How, then, arises the mischief?

The truth is that, in taking air into the lungs and breathing it out again, we breathe out with it certain organic poisons. About the existence and presence of these poisons there can be no doubt, though very little is known about their nature. Of them Dr. Foster writes (page 552) that they may be formed in the lungs, or may be products of putrefactive decomposition allied to a class of poisons known as ptomaines, which are found in the system. Dr. A. Ransome (Health Lectures, 1875–'76, page 160) says:

> The aqueous vapor arising from the breath, and from the general surface of the body, contains a minute proportion of animal refuse matter, which has been proved, by actual experiment, to be a deadly poison. . . . It is this substance that gives the peculiar, close, unpleasant smell which is perceived on leaving the fresh air and entering a confined space occupied by human beings or other animals, . . . and air thus charged has been fully proved to be the great cause of scrofulous or tubercular diseases, and it is the home and nourisher of those subtle microscopic forms of life that have lately become so well known under the title of germs of disease, or microzyms. It is probably the source of a large part of that increase of mortality that seems inevitably to follow the crowding together of the inhabitants of towns.

Galton says (Our Homes, page 497): "This organic matter (given off from the lungs), on an average, may be estimated at thirty or forty grains a day for each adult";† and both Dr. Carpenter and Sir Douglas Galton notice that if breath be passed through water (and then kept in a closed vessel at a high temperature), putrefaction is set up, and a very offensive smell is given off.‡

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* It must be remembered that the act of breathing consists in bringing the blood of the system in contact with air, through a delicate membrane in the lungs. Here an exchange takes place—oxygen being yielded up from the air to the blood, and carbonic acid from the blood to the air.

† We do not know on what exact grounds this calculation rests.

‡ Foster (p. 552) states that "when the expired air is condensed . . . the aqueous product is found to contain organic matter, which, from the presence of micro-organisms, . . . is very apt rapidly to putrefy." L. P. writes: "If a globe be filled with ice and taken into a close, badly ventilated room, the dew which forms outside is found to be contaminated with these organic impurities." L. T. writes: "It is more than likely that it is this animal poison which is the *direct* cause of typhus fever as that follows overcrowding with mathematical precision."

Now let us take the case of a person who sits in a closely shut up room, ten feet high, ten feet broad, and fifteen feet long, for five hours.* At the end of that time he is breathing air which contains 1·2 per cent less oxygen than it ought to contain, but, what is far more serious, he is breathing some air which has already passed through his lungs, and which is charged with this special poison. Here is the great secret of the fatal mischief. Nature has got rid of the poison, thrown it out of the system, but the perverse occupant of the room insists on thwarting Nature, and, by means of his closed doors and windows, breathes in again, it may be a second time or a third time, the poison that has once been safely got rid of. Say that in twenty-four hours 500 cubic feet have passed once through the lungs, then in six hours our friend will have vitiated one quarter of that quantity, or 125 cubic feet—i. e., one twelfth of the whole air in the room (1,500 cubic feet). If he still goes on sitting in his study, at the end of nine hours he will have vitiated 187·5 cubic feet, or one eighth of the whole; or, if he has been unfortunate enough to have a friend sitting with him, then in six hours they will have tainted one sixth of the air; and of every mouthful of air they breathe after that time, one sixth of it must be supposed to be charged with poisons that have been already once got rid of, but are now being retaken into the system. Of course, this proportion of one sixth will not remain constant. Each breath expired will make the matter worse.

A few words seem necessary here for those who have never followed the changes going on in the body. We know that we are constantly building up new tissue of different kinds, and that this building up makes it necessary that the old tissue should be got rid of. The larger part of our food measures this change which is going on. If we take our daily food, liquid and solid, for twenty-four hours, as weighing about five pounds eight ounces (Hermann, page 233)—a large proportion being water—we may look upon about five pounds three ounces of this quantity as used for the making of new tissue, the other five ounces forming what is spoken of as exhausted ferments, and which, passing along the alimentary canal, is eventually rejected. Now, all the suitable part of the food, after undergoing various changes, which are necessary to prepare it for its passage from dead food into living tissue, finds its way into the blood; and when by means of the larger blood-vessels it reaches the very minute blood-vessels, called capillaries, it pours a part of itself out through the per-

* A considerable quantity of air, however, is always entering through window frames, under doors, even through brick walls. On the other hand, we have made no allowance either for space occupied by furniture or for the (probably) tainted condition of the room.

meable walls of these minute vessels, bathing and feeding the whole surrounding tissue. Thus, as somebody has said, the whole of the new and living body is in solution in this wonderful food-stream of the blood, which, by a very subtle mechanism of nerves, distributes its good gifts in proportion to the needs of each separate part. But the blood is not simply a food-stream, it is also a sewage-stream, and it is as such that we are specially interested in it. Where no growth or storing of flesh material of any kind is taking place in the system, it is evident that that part of the daily food which is turned into tissue measures not only the daily construction that is taking place within us, but also the daily destruction or waste. In fact we—if we may so speak of the particles of which we are composed—are forever living and dying within ourselves—making a new self, and getting rid of an old self; and just as the new living body is in solution in the blood, so also is the old dead body, that has done its work and has to be got rid of. Now, of this dead body a large part has to escape through our lungs and through our skin.

About this process of waste very little is known. We know, while certain temporary forms of waste are found in muscle, such as kreatin (Gr. *kreas*, flesh), which, whether again made use of or not (M. Foster, page 154), is supposed to be eventually changed in some complex manner into urea in the liver (M. Foster, page 755), and an acid called sarcolactic (Gr. *sarx*, flesh; *gala*, milk), which is also supposed to be decomposed in the liver into carbonic acid and water (M. Foster, page 826), that all our dead tissue is, with a certain slight but most important exception, got rid of safely at last, as urea, carbonic acid, and water.* These are the final forms which the waste that passes from the tissue into the blood takes—the urea being separated from the blood and got rid of by the kidneys, the carbonic acid both by the skin and the lungs, and the water by all three channels of separation.†

But we said that urea, carbonic acid, and water did not account for quite all the waste tissue; and among the part not so accounted for are the very hurtful poisons which escape from lungs and skin. What are these poisons? Have they a connection with or a resemblance to the poisons which, as we know, exist at all times within the system on a large scale. Dead or waste tissue probably passes through many forms before it reaches the safe final forms of carbonic acid and water, and we must conclude

* We are not taking into account certain other substances discharged from the skin in small quantities.

† "The natural waste of the body appears in two simple forms of carbonic acid—the gaseous form having the chemical formula CO_2O, while that which is got rid of in solution is urea, that is, $CO_2(NH_2)^2$, in which the second atom of oxygen in the carbonic acid is replaced by a nitrogenous body termed amidogen."—(L. P.)

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that some of these forms are highly poisonous. We see this by what happens to a man when he is drowned. A drowned man is in reality a poisoned man. The waste which is going on everywhere and at every moment in his tissues is producing a poison of so deadly a character that when it can not be oxidized by receiving oxygen from the blood (as it does under ordinary circumstances by means of the two gallons (nearly) of air he breathes in a minute) death ensues in a few minutes. In this case the poison produced all over the system has been no longer rendered harmless by oxygen, and goes as poison to the brain. Now, this poisoning does not appear to be primarily or necessarily due to an excess of carbonic acid, which also accumulates in the blood when a man is drowned. As Dr. Foster shows, even where carbonic acid is got rid of and no oxygen available the same result follows. Thus we have a pretty clear indication that the poisoning which results is the non-oxidization of certain active poisons. Other indications point to the same conclusion. When a man faints from loss of blood he probably faints because the diminished stream of blood does not carry a sufficient quantity of oxygen with it to neutralize the poisons which reach the brain.* It is also noticeable that in both these cases convulsions occur—that is, oxygen being denied, the poisons (which retain all their virulence, from being non-oxidized) act as a very powerful stimulant on a part of the nervous center, which, in turn acting through the nerves, throws one set of muscles after another (connected with the respiratory system) into action, in order to obtain the oxygen that is absent; ending at last in that general violent movement which is called convulsions. After a short time the poisons overpower the nerve-centers and death ensues.†

Both fevers and violent exercise seem also to illustrate the same thing. In fever the tissue rapidly wastes, and great quantities of waste poison are poured into the blood. These poisons affect the nerves, and are the cause of quickened respiration, and often of quickened circulation,‡ which are necessary in order to

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* One of the writers was informed by a friend in Africa that he was present when a man cut himself badly with a bill-hook and was carried into a cabin. Each time the door was closed the man fainted; each time the door was thrown open he came back to his senses, indicating pretty clearly that the supply of oxygen, which was unduly diminished by the loss of blood, was increased when the door was open, and was just sufficient to neutralize the effect of the waste poisons and prevent unconsciousness.

† It is interesting to remark here that this reaction of the nerve-center under the effect of the poison seems to be of that "protective character" which occurs so often, and to which Prof. Foster more than once has referred—that is to say, that it produces a violent movement of the muscles in the effort to obtain air, which can alone neutralize the mischief.

‡ In certain cases, however, the heart and circulation are slowed, not quickened. This is the case, Dr. Foster says, in drowning after a slight quickening has taken place. May

get the excess of poison oxidized; when, therefore, unconsciousness supervenes, we may say pretty confidently that the rapid circulation and the rapid breathing have not been sufficient to oxidize and neutralize the mass of poison which is being carried to the brain.* So, again, in pneumonia the quickened breathing shows both the effort of Nature to make up for the loss of that part of the lung which is ineffective, and also the stimulus which the increased waste poison in the blood (increased owing to diminished lung capacity, and therefore diminished oxygen) exerts upon the respiratory machinery. So, again, when less blood is carried to the lungs, owing to the artery which leads from the heart to the lungs being partially blocked with a clot, the same effect is produced. Probably a somewhat similar condition arises after hard work, either in old age or in a feeble state of health. The tissue, not being in the firm condition of the tissue of a vigorous person accustomed to daily work, breaks down in large quantities, while at the same time the circulatory and respiratory machineries are no longer at their best, and therefore the oxidation is imperfect. On the next day the infirm man is poisoned by the unusual quantity of waste in the system, and feels discomfort in many parts of his body or limbs. So, also, the discomfort acutely felt by some persons during east winds probably arises from the poison that ought to have been got rid of by the skin, but, owing to the closing of the pores, has been thrown back into the system. So also with ordinary violent exercise. When we take violent exercise an unusual quantity of waste is thrown into the blood, requiring an unusual quantity of oxidation. Here also the waste stimulates the nerve-centers, increasing action of heart, and of respiratory muscles, so that the blood charged with waste and the air may come into quicker contact. The successful ath-

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this not be explained by the supposition that, where oxygen is altogether denied, an increase in the rapidity of the circulation would carry the poison quicker to the brain, and therefore hasten the end? A different effect seems to occur in the case of vitiated air. In this case Müller asserts (as quoted by Mr. Angell, Manchester Health Lectures, p. 33, 1879–'80) that the circulation is slowed. Is this—if correctly stated—a consequence of the depressing action of these peculiar poisons, which escape with the breath, and are rebreathed in vitiated air? The case of flies which died in foul air with unexhausted tissue, alluded to later on; and some other evidence, seem to point in this direction. In exercise, on the other hand, the effect is, as one would expect, different: both respiration and circulation are quickened in order to increase the supply of oxygen required to meet the large increase of waste; thus it would appear as if the ordinary waste poisons stimulated, while the special poisons of vitiated air depressed. The whole subject calls for very careful consideration. A friend remarks that Dr. Burdon Sanderson, of Oxford, has long been and is working out these questions.

* This indicates very clearly that the purest and freshest air should flow through the room of a person suffering from fever. It would be almost as necessary to him as to the person suffering from loss of blood. Such treatment is confirmed by experience (see case of Austrian army, further on).

lete is, therefore, first the good oxidizer (see M. Foster, page 628), the person who has good lung capacity, and especially a powerful heart to drive the blood swiftly; and, secondly, the person who trains well, whose tissue is healthy and firm and does not break down rapidly into waste—waste in his case not outstripping the powers of oxidation, and thus causing distress. On the other hand, the untrained man, who breaks down in the race with every symptom of distress, is the poisoned man—the man who formed waste quicker than he could oxidize it.*

Reviewing, then, what we have said, we seem to see three things: first, that so long as we have a sufficiency of oxygen, we get rid of a large amount of daily waste in safe and harmless forms; secondly, that when oxygen is withheld from us there are poisons in every part of our tissue of so deadly a character (either abnormally formed because oxygen is absent, or under ordinary circumstances neutralized by the supplies of oxygen present) as to take life in a few minutes; thirdly, that even when all is well, and our system is functioning under healthy conditions, we are still always breathing out from ourselves, through lung and through skin, certain dangerous poisons, which poisons, when we are living in bad air, we perpetually reabsorb into ourselves, to our own great hurt.

Nothing, however, that we have said satisfactorily explains the presence of these poisons which escape from the lungs and the skin. It seems hard to explain why, when Nature so successfully

* In such a case it may be asked, Why are not the waste poisons passing into the blood from the tissues safely got rid of in the form of carbonic acid and water when the blood reaches the lungs? It seems difficult to escape from the conclusion (see Foster, p. 603) that these unoxidized waste products may, on occasion, pass the lungs without being got rid of. In the case of violent exercise, it would seem that the quickened heart and quickened breathing must come from the action of waste poisons, which, passing the lungs, reach the medulla and stimulate the nerve-centers, there not having been time, owing to the excessive quantity of waste produced, to reduce all the waste to the safe final products of water and carbonic acid, and therefore some part of the waste in an unoxidized state being carried past the lungs on to the nerve-centers. As regards the poisons we rebreathe from the air, it is, of course, rather a surprising thing, if they entered the circulation, that they should not be oxidized in the blood when we think of how they must be surrounded by the oxygen that the blood has received from the air. But active as oxygen is—in its "nascent" state, just released from hæmoglobin—in the tissues after leaving the blood, there are reasons for thinking that this activity does not exist in the blood itself. Thus we are told that pyrogallic acid, which is an easily oxidizable substance, may pass through the blood without undergoing any change; and fresh blood, as we are told, has little oxidizing effect. This strange powerlessness of the oxygen in the blood increases the danger of these waste poisons. If they were oxidized in the blood we should be able probably to get rid of them quite harmlessly, as they would not be in the condition of poisons when they escaped from lungs and skin; but we may feel sure that there is some good reason why this can not take place. When they are once carried to the tissues, except in the case of persons taking plenty of exercise and leading a healthy life, there may be no superabundance of oxygen, but rather a deficiency, for all the work to be done.

breaks down the great mass of waste into harmless products, there should be this comparatively slight residue left over—reminding one of a lawless fraction of people in an orderly state—which can not be got rid of on the same easy terms. As we have seen, we have about five pounds three ounces of daily waste that is safely got rid of as urea, carbonic acid, and water, by means of kidneys, skin, and lungs; but accompanying this safe discharge we have a few grains of poison—a sort of surplus of evil—which in some way or other seems to resist the oxidation to which all the other mass of waste has been subject. What, then, is this poison? How far is it the same, how far does it differ from the normal poisons of the tissues, which, as we see, in a few minutes destroy life when oxygen is withheld? Where and how is it formed? Are we to look upon it as a putrefactive poison formed at the surface of the lungs and the skin, when waste of some kind is escaping through these channels? Dr. Klein tells us (pages 61 and 241) that septic bacteria* (the authors of putrefactive change) are to be found in those parts of the body into which air penetrates, as the mouth, the air-passages, the whole alimentary tract; but it seems difficult not to believe, whatever changes take place as these poisons reach the air, that they must at all events have existed as chemical poisons when still in the tissues. Are we, then, to look upon these poisons as derived from putrefactive decompositions taking place in certain parts of the body; or as poisons derived from the tissues; or as in turn possessing both characters? At present, both within and without the body, their nature is surrounded with mystery, and many are the interesting questions that remain to be solved about them. When they have passed outside the body, are they the food of any of the bacteria which are found so plentifully in foul air?† If so, are the ordinary bacteria (excluding the case of certain bacteria producing disease) our friends or our enemies; do they render the poison itself harmless; or do they themselves produce an excretion which is of a poisonous character; or should they be looked on as neutral, destroying one poison and producing another; are the poisons themselves simply removed by currents of air, or are they oxidized in the air; if so, are they oxidized only when ozone is present (see Our Homes, page 11); and if in the air, why not in the blood, after we have rebreathed them and surrounded them with oxygen, in loose combination with hæmoglobin?‡

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* For a different view, see De Bary on Bacteria, p. 44.

† *Bacteria* (Gr. *bakterion*, a staff) are the smallest living organisms known, and generally included in the vegetable kingdom. They possess a very simple structure, are capable of free movement, and multiply very rapidly. Some kinds are the causes of putrefaction and of certain diseases. It is calculated that we inhale 300,000 germs of these organisms in the day.

‡ Mr. Wager adds the following note: "The bacteria on the surface are constantly at

Another light is thrown upon the waste poisons of the tissues by the statement that they exhaust the power of muscle to contract. Muscle taken from a freshly killed animal, if fed with arterial blood, or blood supplied with oxygen, may retain for some time its power of contraction. But if venous blood (blood that has lost its oxygen and is charged with waste poisons) be injected into it, the power of contraction is lost quicker than if no blood be supplied to it. In the same way the power of the muscle is soon exhausted if a solution containing substances which can be extracted from muscle (such as kreatin, lactic acid, etc.) be injected into it (M. Foster, page 150). These facts help us to see the local mischief which must often arise from these poisons, as well as their effects on the nerve-centers. Many an ache and pain are probably due to local effects of the waste poisons, whether they are the normal waste poisons of the system, which under unhealthy conditions of life we are not properly getting rid of, or the special waste poisons of skin and lungs that we have rebreathed into the system.*

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work excreting. At every breath we give off a small quantity of poison, whether we are breathing in pure or bad air. The quantity given off is extremely (extraordinarily) small —so small that it can only be approximately measured by the amount of carbonic acid in the air. These bacteria are present whether we live in foul air or pure air. Their existence there means that they can thrive, and if they thrive they must feed, and if they feed, they must excrete, or something analogous to it. Personally, I am inclined to think they (these special lung and skin poisons) come from the blood, because ptomaines can be formed by the action of various chemical agents (such as acids) upon protoplasmic or albuminous material, and as blood (serum) is albuminous, and as it contains various substances derived from tissue waste—e. g., lactic acid, uric acid probably, etc.—it may be that the two react upon one another, producing these ptomaine-like poisons. I think, however, that it is just possible that they may be formed on the surface.

* Where Nature does not get fair play, where, for example, the blood is vitiated by our constantly rebreathing poisons that have been already got rid of, other dangers probably exist. In the delicate chemical translations which take place when tissue is being changed into harmless waste, it may happen that the process goes wrong, and an abnormal poison is formed. Thus, under certain circumstances, instead of urea, uric acid is formed; thus in uræmia, or retention of urea in the system, various secondary compounds are formed (Carpenter, p. 448), which act on brain or spinal cord as narcotic poisons; thus, in acute yellow atrophy, where liver-cells lose a part of their activity, a substance called leucin is manufactured to a considerable extent instead of urea (M. Foster, p. 755); thus gall-stones are formed instead of gall, and certain changes take place in the bile, by which some of its constituents cease to be dissolved in it (M. Foster, p. 431); thus the ptomaines—a class of mysterious poisons—are formed in the system (Quain, Ptomaine, p. 1816) after various illnesses. [In connection with these ptomaines a dispute arose during an Italian trial as to whether a poison detected in a body was strychnine, or this naturally formed ptomaine.] Thus, too, Blythe (Poisons, A. W. Blythe, pp. 468–470) describes cases in which narcotic poisons have been formed by synthesis of substances in the tissue or in the blood. So also we might quote the interesting speculation of Dr. Carpenter (p. 368), that a cancer is an excretory organ, formed to get rid of poisons in the system, illustrating once more "the protective nature" even of that which brings pain and death; and the case of certain pathogenic organisms, which, as Dr. Klein suggests (p. 248), may not affect healthy living

We now pass to other evidence affecting the poison that escapes from lungs and skin. We all know that a room is offensive when many people are crowded into it; we know the unpleasantness of a bedroom before the air has freely entered it; we know how disagreeable the breath and the clothes can be; we know that animals die when submitted to air that has been breathed, even when the carbonic acid has been removed;* we know how necessary is the continuous flood of pure air in hospitals—we have heard it stated that this much freer admission of air is rendering unnecessary the antiseptic treatment of wounds; how by treating men in the open air and in tents recoveries have been made quicker and better than in hospital;† and how in the case of the Austrian army "the most severe maladies ran their course much more mildly" in the free air, while the recovery was quicker and more perfect (Ransome, Health Lectures, 1875–'78, page 151). So also Dr. Parkes says (page 181) in cases of blood-poisoning, the best treatment is complete exposure to open air; so also in typhus; and in a less degree in enteric fever, small-pox, and plague. "This complete exposure," he adds, "of patients to air is the most important mode of treatment, before even diet and medicines."‡ In

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tissues, but only diseased tissues—the disease implying alteration of the tissue. All these cases are cases, doubtless, of an extreme kind; they imply the abnormal formation of poisons to a serious extent, sufficient to constitute illness; but it may well be that there are many less serious formations of abnormal poisons, which, though not sufficient to produce illness, yet cause much discomfort, and which are the consequence of the vitiated state of the blood, arising from the habitual breathing of impure air.

* If we remember rightly, both Parkes and D. Galton (Our Homes) refer to these experiments—a mouse dying in forty-five minutes when submitted to air treated in this manner. Dr. Richardson also refers in one of his works to experiments, which were conducted by himself, and which are more fully described in a report to the British Association. Dr. Richardson had formerly a theory of "devitalized oxygen," but we suppose he would probably consider now that it was a truer statement to say that this special poison had not been removed from the air which the creatures breathed. Experiments of the same kind have also been made on rabbits in Paris. One of our number (A. H.) adds the following remark: "Though I think probably it would be quite misleading to speak of the experiments upon the mouse, and the experiments conducted by Dr. Richardson as in any sense cruel, yet, speaking my own personal opinion, I remain opposed to all such experiments. While I admit the neat and convenient evidence often supplied by them, and also admit that difficulties of method would at first exist, were they renounced, yet I think the wealth of materials that exist on all sides of us for pushing forward knowledge is so vast, that however convenient these experiments may be, they are not really necessary, while perhaps a keener perceptive sense in tracing out the meaning of the things of common life, which are of such vital importance, would be developed, as investigators renounced this particular method. In writing this, however, I am governed by the moral side of the question, which is the one that, apart from all other considerations, determines my view."

† The case of the hospital is, of course, a complicated case, and it might be disputed how far its evidence can be used for our purpose.

‡ "When our health commissioners were sent out to the Crimea to examine the heavy mortality among soldiers in the hospitals, their first act was to use their sticks to break

the same way, the deaths of the Black Hole of Calcutta add their evidence, though it is an evidence of an extreme kind. While out of the one hundred and forty-six persons shut up, one hundred and twenty-three died, of the remaining number (Carpenter, page 357) many afterward died of putrid fever—that is, were poisoned, owing to an insufficiency of oxygen to neutralize the poisons breathed out on all sides of them, and rebreathed by themselves. A much simpler piece of evidence is presented to us daily by our own eyes. Who is not struck by the pasty, anæmic look of our city children, and of the large number of those who follow sedentary occupations, as contrasted with the looks of those who live in the country and are much in the open air? What is that pasty, anæmic look? It is the absence of red corpuscles from the blood, indicating that where oxygen is deficient * the red corpuscles are not produced in their proper quantity. So also the effects of living in rooms in which sewer-gas has penetrated illustrate in their own stronger degree the effects of living in unventilated rooms. The one is the lesser form, the other the more serious form of the same evil. In both, bacteria thrive and multiply, and in both, meat and milk rapidly taint. They are both full of organic matter, and the symptoms of headache and feverishness are common to both, though, of course, the case of sewer-gas is much the more acute case. † Again, we all know the wonderfully restoring effect that hill air with its ozone has upon us after town life; showing how the poison has depressed all our functions, and how the pure air restores their energy. We see the same effect in the lives of work-people. Sir D. Galton, as we have seen, tells us of better work done, more energy, more appetite, when air is introduced into unhealthy work-rooms. Dr. Parkes tells the same story. Dr. A. Ransome, speaking in 1875, quotes the case of the Guards, picked men, highly cared for, yet who died quite as fast as the civil population. Why? he asks. Mainly from defective ventilation of the barracks (Health Lectures, 1875–'78, page 150).‡

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some hundreds of glass panes in the windows, so as to admit air freely. After that the wounded recovered rapidly."—(L. P.) In the same way Dr. Clifford Allbutt reduced the mortality in a heavy epidemic of typhus fever in Leeds by fastening the windows in the fever hospital with screws, so that they could not be shut. He remarks that in Ireland those attacked with typhus, who were put out to die, would often recover.

* But why is oxygen deficient in these cases? Is it, once more, because so much organic poison is breathed in with the air of the shut-up rooms, that the functions are depressed and imperfectly performed; that, for example, the act of respiration is impaired? Or does the poison directly affect the formation of the red corpuscles?

† It has, however, been shown recently that the air in a well-ventilated sewer is, so far as organic matter and micro-organisms are concerned, purer than the air in a small, badly ventilated room.

‡ "Sir Lyon Playfair, one of the commissioners for inquiring into the state of barracks, passed a couple of nights with the soldiers in their crowded sleeping-rooms, and found the

Again, we find disease attacking country districts for the first time, where houses had been improved, and the ventilation, which used to take place through porous walls and less well-fitting windows, has been done away with.* So also it is stated by Mr. Angell (Health Lectures, 1879–'80, page 31) that in the old crowded lodging-houses people sleeping on the floor would escape fever, while those sleeping on the bedsteads would be struck by it. Those on the floor got ventilation from the door and fireplace; those on the bedsteads were above the line of it—the colder

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air saturated with organic effluvia which discolored permanganate of potash. The mortality among soldiers is now greatly reduced by the better ventilation enforced by the commission."—(L. P.)

* A case of this kind is reported to us by Mr. Alexander Campbell, of Auchindarroch, Lochgilphead; and we believe that the same thing was observed in a Westmoreland district. In an interesting letter Mr. Campbell writes: "Some years back I was asked by a medical officer of large experience in the Highlands regarding a phenomenon which had puzzled him. He had exerted himself much, and with great success, to have improved cottages built, but in proportion as the cottages grew better did the health of the people grow worse. I gave him my opinion that in the old, uncomfortable-looking cottages, built may be of dry stone, and open to the roof, the people were kept healthy in spite of themselves by the wind blowing through them, while the new cottages, tightly built, and with well-fitting doors and windows, excluded the air, and the windows being seldom or never opened, the inhabitants were poisoned. He said he fully agreed in this, and would ask for no more new cottages until the people had learned how to live in them. I have found a considerable amount of ill health among the paupers in the island of Tiree, which, from its situation, exposed as it is to the free action of breezes from the Atlantic, should be one of the healthiest islands of the Hebrides. I attribute this to the mode in which the houses are built, with two walls two or three feet apart, the interval being closely packed with sand. The air is thus hermetically excluded, and unless the windows are made to open, and are freely opened, the inhabitants are constantly, when within their dwellings, breathing vitiated air." It is also worth while quoting from a review of Major Fisher's book (which book we have not read) in The Spectator, May 2, 1891, Through the Stable and Saddle Room: "Everybody knows something of the importance of ventilation, both for man and horse; but it is not so widely known as it ought to be that, while horses seldom or never take cold through being exposed to cold, they are often made ill by being too warm. [It is not the warmth; it is the impure air.] It is the inside, not the outside, air that gives them coughs, sore throats, congestion of the lungs, and sundry other ills to which horse-flesh is heir. For this reason, old ramshackle stables, full of cracks and crevices, are healthier than brand-new buildings with tight doors and windows and impervious roofs. Our author, who never generalizes rashly, and supports his theories with copious instances, mentions one or two curious 'cases in point.' Remounts for cavalry regiments, which are mostly of Irish extraction, have often to travel in severe weather part of the way in cattle-trucks, with no other protection from the cold than their own coats. Nevertheless, the remounts nearly always arrive at their destination in perfect health; yet they are no sooner placed in stables, however well ventilated, than they begin to suffer from coughs and colds, which generally end in strangles. During the autumn manœuvres of 1875, Major Fisher's regiment was encamped near Aldershot, and though it rained almost incessantly, and the horses were picketed in the open, without so much as a blanket to cover them, colds and coughs were unheard of, and the favorite charger of one of his brother officers, which at the time she left the barrack-stable suffered from a severe cold, was made whole by a few days' exposure to the elemental strife." The book should contain some valuable facts.

and purer air being heavier than the heated impure air, and therefore nearer the line of the floor.

Animals furnish the same evidence. Cows and horses both suffer grievously from want of ventilation in their stables; and cattle, though they require warmth for fattening, still put on flesh better in a colder but well-ventilated place than in a warmer place which is unventilated (Parkes, page 180). So also Parkes tells us about the French cavalry. Before 1836 the mortality among the horses varied from 180 to 197 per 1,000 per annum. With the enlargement of the stables and increased quantity of air, the loss was reduced to 68 per 1,000, and finally to 28½ per 1,000, and of officers' horses to 20.

Then we have the evidence of the ordinary tests for ascertaining the purity of the air. Air fouled by respiration discolors permanganate of potash and robs it of a portion of its oxygen; the amount of organic matter is then measured by the number of volumes of oxygen required to reoxidize the permanganate and restore it to its former condition. Another test is the presence of certain bacteria, which are found in large numbers in foul air, increasing out of proportion to the molds or fungi found in the air, which appear to be much less affected by impurities. It is stated that these forms of life all originally come from the open air—that reservoir of all things—though they are supposed to multiply in congenial quarters when once they have found an entrance. The significant fact, however, is their number, which might seem to show that they prosper just because they have discovered their proper food—the organic poison which is poured out into the air from our lungs and skin. On this point, Dr. A. Ransome makes an interesting speculation, which we quote from memory—a wrong thing to do. Impressed with the belief that consumption is communicable in foul air, and non-communicable in good air, he believes that the bacillus (a form of bacteria) which conveys the disease retains its virulence more in foul air than in pure air, and is thus better able to make a lodgment in the human system.*—*Contemporary Review.*

[*To be concluded.*]

* This speculation of Dr. A. Ransome's suggests another speculation. Dr. Klein (pp. 238–248) believes that in the interior of healthy human tissue no bacteria, which cause putrefaction, are found. They are found abundantly in those parts of the system to which air penetrates, as, for instance, in the mouth, or in the alimentary canal; and from the alimentary canal they pass easily, as the food itself does, into the diminutive blood-vessels or the diminutive lymphatics (locally called lacteals) that line the walls of this canal. But if the blood is in healthy order they seem to perish, dying for want of food. Dr. Klein goes on to state that if at some point they are carried to tissue that is in an unhealthy condition, there they may obtain a footing and begin to multiply. He does not actually state, as we understand, that the unhealthy condition of the blood keeps them alive, but he implies it; and it would seem probable that the unhealthy state of the blood—for ex-

SKETCH OF JOHN AND WILLIAM BARTRAM.

DURING the century which preceded the American Revolution the science of the colonies, like their commerce, was tributary to that of the Old World. Fabulous reports in regard to the natural resources of America had been brought home by European voyagers, and the cultivators of all sciences and arts were looking to that vast unexplored region for products which should increase the knowledge of the naturalist, the resources of the physician and the agriculturist, the profits of the merchant, and the enjoyment of the man of leisure. The function of those colonists who inclined to natural history was that of explorers and collectors, and among the earliest and most notable of these American collectors were the subjects of this sketch.

The grandfather of the elder Bartram, also named John, came from Derbyshire, England, to Pennsylvania in 1682. He brought his wife, three sons, and one daughter, and settled near Darby, in Delaware (then Chester) County. The third son, William, was the only one who married, his wife being Elizabeth, daughter of James Hunt. Both families belonged to the Society of Friends. The children of William were John (the botanist), James, William, and a daughter who died young. The second William went to North Carolina and settled near Cape Fear; John and James remained in Pennsylvania.

The date of JOHN BARTRAM'S birth was March 23, 1699. But little is on record concerning his early years. Like the majority

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ample, blood charged with poison which have escaped from the skin and lungs, and been rebreathed into the system—would have the same favoring effect upon them as the unhealthy tissue. Both are likely to present them with the food they require. If this be so, then just as the bacteria that cause disease are favored by the external poisons they find in vitiated air, so also they may be internally favored by the unhealthy state of the bronchial and lung tissues of those persons who habitually breathe the poisons of shut-up rooms. Thus, these organic poisons, both within and without a man, would tend to make him a prey to those illnesses in which the success of the germ depended upon its proper—might we say—food being supplied to it; and it would seem probable that, by constant attention to the purity of the air which we breathe, we might do much toward securing individual exemption from the danger of infectious diseases. An instructive passage in Dr. Carpenter (p. 365) which bears on this point should be read. It is also worth quoting Prof. Nussbaum (see an interesting article by Mrs. Priestley, May, Nineteenth Century, p. 825): "It is known with certainty that the cholera bacillus is dangerous only to those persons whose stomach is not in a healthy state, and jeopardizes life only when it passes into the intestines. A healthy stomach will digest the bacillus, and therefore it does not reach the intestines in a living state." It is, perhaps, right to refer here to a theory that in the blood and connective and lymphatic tissues (Klein, p. 243) there exists a clan of protective cells (phagocytes), whose office it is to overpower invading bacteria of a dangerous character; and, according to Metschnikoff (Ann. de l'Institut Pasteur) these can, in case of need, emigrate to any part of the body which is invaded by parasites.

of boys in the colonies, he was brought up to a farming life, and his education was only such as the country schools of the time afforded. After reaching adult years he studied Latin a little, so as to be able to pick out the descriptions of plants in the Latin works of European botanists. In a sketch of John Bartram, written by his son William, it is stated that he had an inclination to the study of physic and surgery and did much toward relieving the ailments of his poor neighbors. In January, 1723, he married Mary, daughter of Richard Morris, of Chester Meeting, by whom he had two sons—Richard, who died young, and Isaac, who lived to old age. His wife Mary died in 1727, and in September, 1729, he married Ann Mendenhall, of Concord Meeting, who survived him. John and Ann Bartram had nine children, five boys and four girls. Of these the third son was WILLIAM, he and his twin

BARTRAM'S HOUSE IN 1887. (From a photograph furnished by Mr. Thomas Meehan.)

sister, Elizabeth, being born February 9, 1739. The ground on which John Bartram laid out the first botanic garden in America was on the west bank of the Schuylkill River, at Kingsessing, near Gray's Ferry (now within the city limits of Philadelphia), and was bought by him September 30, 1728. "Here he built with his own hands," says William, "a large and comfortable house of hewn stone, and laid out a garden containing about five acres." A view of this house, which is still standing, is given in the

accompanying picture. The year of its erection is shown by a stone in the wall on which is cut "JOHN * ANN BARTRAM, 1731." Another inscription on a stone over the front window of his study reads:

"'Tis God alone, Almighty Lord,
The Holy One, by me adored.
"JOHN BARTRAM, 1770."

That the building was a labor of love is attested by the care bestowed upon the carved stone-work around the windows and doors and the pillar under the porch. John Bartram must have been a good stone-cutter and mason, for this was one of four stone houses that he built in his lifetime.

Nearly all the extant information concerning the lives of the two Bartrams has been embodied in the Memorial of John Bartram, by William Darlington, published in 1849. This volume contains the sketch of John Bartram by his son William, with some additions by the editor, and over four hundred pages of correspondence. About a fourth of these letters are from his friend Peter Collinson; the others are from eminent botanists in Europe and America, and from Bartram to these various correspondents. Darlington also reprinted a sketch of John Bartram, which appeared in the Letters from an American Farmer, by J. Hector St. John, published in London soon after Bartram's death. The "letter" describing Bartram purports to be written by a Russian traveler, who is evidently a myth, although in all important respects the account represents the botanist as he was. As to how Bartram's interest in botany was aroused, the "Russian gentleman" has a very pretty story, telling of a sudden conversion after the botanist had married; but Bartram himself is better authority, and he writes to Collinson, May 1, 1764, "I had always since ten years old a great inclination to plants, and knew all that I once observed by sight, though not their proper names, having no person nor books to instruct me."

He was encouraged to study systematically by James Logan (founder of the Loganian Library, in Philadelphia), who gave him several botanical works. In order that his explorations, begun at his own expense, might be extended, Bartram's friends prompted him to seek the patronage of some wealthy and influential person in the mother-country. Accordingly, a quantity of his specimens and a record of some of his observations were sent to Peter Collinson, a Quaker merchant in England, who was greatly interested in horticulture. Bartram's consignment secured his interest, and led to a correspondence, which lasted nearly fifty years. The first letter in Darlington's collection is from Collinson, under the date January 20, 1734–'35, and refers to letters from Bartram of the preceding November; hence this correspondence probably

began when Bartram was about thirty-five years of age. In his early letters Collinson makes many inquiries about American plants and requests for specimens. He sends Bartram seeds, roots, cuttings of trees, vegetables, and flowering plants cultivated in England, packages of paper in which to preserve specimens, and gives him directions for collecting and drying plants. From time to time he sends presents of cloth and other articles for the use of the botanist or his family. For Bartram's "improvement in the knowledge of plants" he early offers, if duplicate collections are sent, to "get them named by our most knowing botanists, and then return them again, which will improve thee more than books." In this way the learning of Dillenius, Gronovius, and other eminent men was brought to the aid of the humble colonist. Collinson obtained for Bartram many orders for seeds and roots of American plants, and early secured for him the patronage of Lord Petre, whose gardens and hot-houses were probably the most extensive in the kingdom. This noble amateur ordered quantities of seeds from time to time, and when Bartram asked for a yearly allowance to enable him to extend his explorations, Lord Petre agreed to contribute ten guineas toward it. As much more was obtained from the Duke of Richmond and Philip Miller, and the twenty guineas were paid each year till 1742, when Lord Petre died. The first expedition that Bartram made with this assistance was an exploration of the Schuylkill River. He transmitted his journal of the trip and a map of the river to his patrons, and with both of these Collinson reported Lord Petre to be much pleased.

Besides plants, Collinson asks Bartram at various times to send insects, birds, and their eggs and nests, terrapin and other turtles, snakes, shells, wasps' and hornets' nests, and fossils, which last were then regarded as "evidences of the Deluge." "My inclination and fondness to natural productions of all kinds," he writes, "is agreeable to the old proverb, '*Like the parson's barn—refuses nothing.*'" During the second year of his allowance Bartram complains that it does not recompense him for his labors, and he also finds fault with Collinson for giving him seeds and cuttings that he has already, and for not having answered some of his letters. Collinson, in a business-like reply, shows that Bartram's complaints are due to his ignorance of commercial affairs and the difficulty of transatlantic communication, and to his exceeding the commissions of his patrons—whereupon the botanist promptly apologizes.

In 1738 Bartram made a journey of five weeks through Maryland and Virginia to Williamsburg, then up the James River, and over the Blue Ridge Mountains, traveling in all about eleven hundred miles. Most of the botanist's expeditions were made

without any scientific companion. "Our Americans," he writes to a correspondent, "have very little taste for these amusements. I can't find one that will bear the fatigue to accompany me in my peregrinations."

In an undated letter, written probably in 1739, to Colonel Byrd, of Virginia, Bartram reports that he had been making "microscopical observations upon the male and female parts in vegetables." He had also made, he says, "several successful experiments of joining several species of the same genus, whereby I have obtained curious mixed colors in flowers, never known before." To this he adds: "I hope by these practical observations to open a gate into a very large field of experimental knowledge, which, if judiciously improved, may be a considerable addition to the beauty of the florist's garden." It was in this "field of experimental knowledge"—namely, cross-fertilization—that Darwin afterward won a share of his fame. Bartram evidently discussed this subject with Collinson, for the latter writes in 1742: "That some variegations may be occasioned by insects is certain; but then these are only annual, and cease with the year." Permanent variegations, he says, are produced by budding—a sort of inoculation.

That Bartram had a hostility to superstition, tempered with much considerateness for persons, is shown by a letter in which he tells of a visit to Dr. Witt, of Germantown, another of Collinson's correspondents. He says: "When we are upon the topic of astrology, magic, and mystic divinity, I am apt to be a little troublesome, by inquiring into the foundation and reasonableness of these notions—which, thee knows, will not bear to be searched and examined into: though I handle these fancies with more tenderness with him than I should with many others that are so superstitiously inclined."

One of the botanists whose offices Collinson had secured in identifying Bartram's specimens was Prof. Dillenius, of Oxford, and in 1740 Collinson writes for some mosses for him, saying, "He defers completing his work till he sees what comes from thee, Clayton, and Dr. Mitchell." In the same year a list of specimens which had been named by Dr. J. F. Gronovius, of Leyden, was returned, and contained this entry: "*Cortusæ sive Verbasci*, Fl. Virg., pp. 74, 75. This being a new genus, may be called BARTRAMIA." The name Bartramia is now borne by a different plant—a moss growing in the Berkshire Hills of Massachusetts.

Bartram's correspondence with Gronovius began about 1743, and extends over a dozen years or more. Gronovius writes at length, very appreciatively, and makes many requests. He sends his books as they appear, and before the publication of his Index

Lapidæ, sends a transcript of the passage, in Latin, in which he is to give Bartram credit for his fossil finds.

Among the European scientists whom Collinson made acquainted with Bartram's work was Sir Hans Sloane, physician and naturalist, who succeeded Newton as President of the Royal Society. At his request Bartram sends him, in 1741, some "petrified representations of sea-shells." The next year Sloane sends to Bartram a silver cup inscribed:

"The gift of S^{r} Hans Sloane, Bart.
To his Fr^{d} John Bartram.
Anno 1742."

A figure of this cup is given by Darlington. Sloane also sent Bartram his Natural History of Jamaica, in two ponderous folio volumes.

About this time a correspondence began between Bartram and Dr. John Fothergill, a wealthy physician and naturalist, who, like Sloane, had first received some of Bartram's specimens from Collinson. Dr. Fothergill wishes to know what mineral springs there are in America, and Bartram sends him what information he has and can get from others.

Bartram also exchanged letters with Philip Miller, author of the Gardener's Dictionary, with George Edwards, who in 1766 sends his book, containing descriptions of birds that the Pennsylvanian had sent him, with Prof. John Hope, of Edinburgh, and with the ablest observers of nature in the colonies, among whom were Dr. John Mitchell, Rev. Jared Eliot, John Clayton, Cadwallader Colden, and Dr. Alexander Garden.

In 1744 he writes, "Dr. Gronovius hath sent me his Index Lapidæ, and Linnæus the second edition of his Characteres Plantarum, with a very loving letter desiring my correspondence, and to furnish him with some natural curiosities of our country." The same year he sends to England his Journal of the Five Nations and the Lake Ontario, describing a journey he had made the preceding fall. It contained an account of the "soil, productions, mountains, and lakes" of those parts of Pennsylvania and New York through which the route lay; and gave the proceedings of a great assembly of Indian chiefs held to treat with the agent of the Province of Pennsylvania, whom Bartram accompanied. This journal was afterward published in London.

The visit of Peter Kalm to America took place in 1748 to 1751. He traveled through Canada, New York, Pennsylvania, and adjoining provinces; made the acquaintance of the Gray's Ferry botanist, and obtained much assistance from him. It has been alleged that Kalm took to himself the credit of some discoveries which rightfully belonged to Bartram. This would not be suspected from reading Kalm's Travels, in which he gives Bartram

a page and a half of hearty commendation, saying among other things: "We owe to him the knowledge of many scarce plants, which he first found, and which were never known before. . . . I likewise owe him many things, for he possessed that great quality of communicating everything he knew. I shall, therefore, in the sequel frequently mention this gentleman." On nearly every one of the next twenty pages credit is given to Bartram for information.

In 1751 Benjamin Franklin and D. Hall published at Philadelphia an American edition of Dr. Thomas Short's Medicina Britannica, "with a Preface by Mr. John Bartram, Botanist, of Pennsylvania, and his Notes throughout the work; . . . and an Appendix, containing a description of a number of Plants peculiar to America, their uses, virtues, etc." The notes told where the plants were found in America, and how they differed from the English varieties.

John Bartram's son William begins to figure in his father's correspondence when about fifteen years old. At that time Bartram sent some of William's drawings of natural objects to Collinson, and took him on a trip to the Catskills. In 1755 Bartram writes: "I design to set Billy to draw all our turtles with remarks, as he has time, which is only on Seventh days in the afternoon, and First-day mornings; for he is constantly kept to school to learn Latin and French." This attention to the languages indicates that Bartram was determined that his son should not suffer from the lack that had limited his own reading of works on natural history. William was then attending the old college in Philadelphia.

The same passage shows also that Bartram's ideas about Sunday occupations were somewhat unusual for that generation, and in fact it is stated that he was excommunicated by his brother Quakers about this time for his independent religious views. The question of an occupation for William now came up, and in the letter just quoted his father asks Collinson's advice in the matter. "My son William," he writes, "is just turned of sixteen. It is now time to propose some way for him to get his living by. I don't want him to be what is commonly called a gentleman. I want to put him to some business by which he may, with care and industry, get a temperate, reasonable living. I am afraid that botany and drawing will not afford him one, and hard labor don't agree with him. I have designed several years to put him to a doctor, to learn physic and surgery; but that will take him from his drawing, which he takes particular delight in. Pray, my dear friend Peter, let me have thy opinion about it." Franklin offered to teach William the printing trade, but Bartram was not quite satisfied with the prospects for printers in Pennsylvania, and

Franklin then suggested engraving. But William became neither printer nor engraver. At the age of eighteen he was placed with a Philadelphia merchant, Mr. Child, where he remained about four years.

Bartram's science was largely practical. He wrote to Dr. Alexander Garden, of Charleston, in 1755, suggesting a series of borings on a large scale, to search for valuable mineral products. He gives as another reason the satisfaction to be derived from knowing the composition of the earth, and adds, "By this method we may compose a curious subterranean map." "This scheme of John Bartram's," says Darlington—"if original with him—would indicate that he had formed a pretty good notion of the nature and importance of a geological survey and map, more than half a century before such undertakings were attempted in our country, or even thought of by those whose province it was to authorize them."

Bartram was evidently much interested in geological subjects; thus, in 1756 he writes, "My dear worthy friend, thee can't bang me out of the notion that limestone and marble were originally mud, impregnated by a marine salt, which I take to be the original of all our terrestrial soils."

In 1760 he makes a trip through the Carolinas, his Journal of which he wrote out and sent to England. The following summer, William, then twenty-two years old, went to North Carolina and set up as a trader at Cape Fear, where his uncle William had settled when a young man. That year John Bartram makes a journey to Pittsburg and some way down the Ohio River, keeping a journal, as usual, which is sent to his English friends. Nearly all of these trips were made in autumn, so as to get ripe seeds of desirable trees and plants.

Bartram had too tender a feeling toward animal life to be much of a zoölogist. He says on this score: "As for the animals and insects, it is very few that I touch of choice, and most with uneasiness. Neither can I behold any of them, that have not done me a manifest injury, in their agonizing mortal pains without pity. I also am of opinion that the creatures commonly called brutes possess higher qualifications, and more exalted ideas, than our traditional mystery-mongers are willing to allow them." His ideas concerning animal psychology were thus clearly in advance of his time.

The war with France, known to Americans as the French and Indian War, resulted in extending the British possessions in America as far west as the Mississippi River. Immediately a desire was expressed in England for a thorough exploration of this great accession of territory. Bartram writes in 1763 that this could not be made without great danger from the Indians. His

own expeditions had been very short during the hostilities. The late war had shown the colonists what atrocities the savages were capable of, and the prevailing feelings toward the red men had become dread and hatred. "Many years past in our most peaceable times," writes Bartram, "far beyond the mountains, as I was walking in a path with an Indian guide, hired for two dollars, an Indian man met me and pulled off my hat in a great passion, and chawed it all round—I suppose to show me that they would eat me if I came in that country again." In two other letters he says that the only way to make peace with the Indians "is to bang them stoutly." The question arises whether the combative disposition of the botanist thus revealed might not have been one of the reasons for his exclusion from the Society of Friends.

In 1764 Bartram sends to England his Journal to Carolina and New River. In this year, one Young, of Pennsylvania, managed to gain the favor of the new king, George III, by sending him some American plants, and obtained sudden preferment. It was said that all the plants had been sent to England before—many of them by Bartram. The friends of our botanist, feeling that he was much more deserving of such favor, urged him to send some specimens to the king, which he does through Collinson, desiring that he may be given a commission for botanical exploration in the Floridas. April 9, 1765, Collinson writes, "My repeated solicitations have not been in vain," and reports that the king has appointed Bartram his botanist for the Floridas, with a salary of fifty pounds a year. This appointment continued till the death of the botanist, twelve years after. Bartram accordingly made an expedition in the South the next fall. He was then sixty-six years old; and, although his eagerness for exploring was undiminished, he felt the need of a companion on this trip, and got William to go with him, the latter closing out his not very successful business at Cape Fear in order to do so. In his sketch of his father, William states that he had been ordered to search for the sources of the river San Juan (St. John's), and that he ascended the river its whole length, nearly four hundred miles, by one bank, and descended by the other. He explored and made a survey of both the main stream and its branches and connected lakes, and made a draught showing widths, depths, and distances. He also noted the lay of the land, quality of the soil, the vegetable and animal productions, etc. His report was approved by the governor of the province, and was sent to the Board of Trade and Plantations in England, by which it was ordered published "for the benefit of the new colony." Bartram collected a fine lot of plants, fossils, and other curiosities on this trip, which were forwarded to the king, who was reported to be much pleased with them. His journal is still extant, in a volume with an Ac-

count of East Florida, by William Stork, published in England. It is evident from this production that the botanist was not a ready writer. His observations are minute and sagacious, and his language is simple, but his sentences are loosely strung out, and the record is the barest statement of facts. His Journal to the Five Nations, however, is much more readable.

William seems to have been much taken with Florida, and accordingly his father helped to establish him as an indigo-planter on the St. John's River. After about a year of disastrous experience he returned to his father's home and went to work on a farm in the vicinity. Collinson had been watching for an opening for William in England, but so far nothing had come of it. The next year he writes that the Duchess of Portland, a "great *virtuoso* in shells and all marine productions," had just dined at his house, and, having seen William's drawings," she desires to bestow twenty guineas on his performances *for a trial.*" The kind of objects she wants drawn are told. The same month, July 18, 1768, Collinson writes to William that he had also secured an order from Dr. Fothergill for drawings of shells, turtles, terrapin, etc. This was probably the last letter of Collinson to the Bartrams, as he died on the 11th of the following month. During his long friendship with John Bartram the two men had never seen each other.

William now began to send drawings and descriptions to Dr. Fothergill from time to time. In 1772 he began explorations in the Floridas, Carolina, and Georgia, the expense of which for nearly five years was borne by Dr. Fothergill, and to him William's collections and drawings were turned over. William made many contributions to the natural history of the country through which he traveled, and in 1791 published his Travels through North and South Carolina, Georgia, East and West Florida, together with an account of the Creek, Cherokee, Choctaw, and other tribes of Indians which he visited. His attitude toward the red men is much more favorable than that of his father. The volume contains many engravings of plants and birds from the author's own drawings. Of this book Coleridge said: "The latest book of travels I know written in the spirit of the old travelers is Bartram's account of his tour in the Floridas. It is a work of high merit every way."

Among the influential friends of the elder Bartram was Benjamin Franklin. While in England Franklin writes to him and sends him seeds of garden vegetables at various times; and when the Revolution had stopped his sending seeds to England, Franklin offers to sell them for him in France.

Among the testimonials to his botanical achievements that Bartram received was a gold medal, weighing 487 grains, from

a society in Edinburgh, founded in 1764, for obtaining seeds of useful trees and shrubs from other countries. This medal is inscribed, "To Mr. John Bartram, from a Society of Gentlemen at Edinburgh, 1772"; and on the reverse, "MERENTI," in a wreath. The medal is figured in Darlington's Memorials, and when that book was published was in the possession of a Mrs. Jones, a descendant of the botanist. April 26, 1769, the Royal Academy of Sciences, of Stockholm, on the proposal of Prof. Bergius, elected Bartram to membership. Another honor that he received from the same country was a letter from Queen Ulrica, and with this may be mentioned the opinion passed upon him by Linnæus, who called Bartram the greatest natural botanist in the world. Bartram was one of the original members of the American Philosophical Society, and contributed many papers to its Transactions.

The closing years of John Bartram's life were the opening years of the Revolution. He was living when independence was declared in the neighboring city of Philadelphia, but died the following year, September 22, 1777, at the age of seventy-eight. A granddaughter, who remembered him distinctly, has stated that he was exceedingly agitated by the approach of the British army after the battle of Brandywine, and that his days were probably shortened in consequence. The royal troops had been ravaging the country, and he was apprehensive lest they should lay waste his darling garden.

His son William describes him as "a man of modest and gentle manners, frank, cheerful, and of great good nature; a lover of justice, truth, and charity. . . . During the whole course of his life there was not a single instance of his engaging in a litigious contest with any of his neighbors or others. He zealously testified against slavery, and, that his philanthropic precepts on this subject might have their due weight and force, he gave liberty to a most valuable male slave, then in the prime of his life, who had been bred up in the family almost from infancy." He was of an active temperament, and often expressed the wish that he might not live to be helpless. This desire was gratified, for he died after only a short illness.

No picture of him is known to exist. In regard to his physical appearance William states: "His stature was rather above the middle size, and upright. His visage was long, and his countenance expressive of a degree of dignity with a happy mixture of animation and sensibility." Concerning Bartram's ability as a naturalist there are enthusiastic opinions extant in letters by Franklin, Collinson, Colden, and others well qualified to judge.

William Bartram, after the death of his father, continued in the pursuit of natural history. The Botanic Garden was inher-

ited by his brother John, who took William into a partnership which lasted many years. After this arrangement terminated, William continued to assist his brother till the death of the latter, in 1812. The garden then descended to John's daughter Anne, the wife of Colonel Robert Carr, in whose family William resided from that time until his death. He was never married. In 1782 William Bartram was elected Professor of Botany in the University of Pennsylvania, but declined the position on account of ill health. He became a member of the American Philosophical Society in 1786, and was elected to other learned societies in both Europe and America. He was an ingenious mechanic, and, as before intimated, was skillful in drawing and painting. Most of the illustrations in Prof. Barton's Elements of Botany were from his drawings. His botanical labors brought to light many interesting plants not previously known. But this was not his only field. He made the most complete and correct list of American birds before Wilson's Ornithology, and, in fact, his encouragement and assistance were largely instrumental in making that work possible. Among William Bartram's scientific correspondents were the Rev. Henry Muhlenberg and F. A. Michaux, to whom he furnished seeds. A manuscript diary of William Bartram, presented to the Academy of Natural Sciences of Philadelphia in 1885, by Mr. Thomas Meehan, is rich in ornithological and botanical notes, and contains also weather notes and records of personal experiences which are of great interest. His death occurred suddenly from the rupture of a blood-vessel in the lungs, July 22, 1823, in the eighty-fifth year of his age. Besides his Travels, William Bartram was the author of Anecdotes of a Crow, and Description of Certhia. In 1789 he wrote Observations on the Creek and Cherokee Indians, which was published in 1851, in the Transactions of the American Ethnological Society, Vol. III.

In the old stone-house the great fireplace has been filled up, but few other changes have been made. The building is full of curious turns and cubby-holes. Connected with a cupboard in the sitting-room is a recess running behind the chimney, which furnished a safe depository in winter for specimens that frost could injure. Back of the sitting-room, in the wing of the building, is an apartment with large windows looking toward the south which was the botanist's conservatory. Here were reared such plants as could not stand a Pennsylvania winter—gathered in Florida or the Carolinas, or sent from Europe. In the grounds close to the river is a great imbedded rock, hewn flat, in which is cut a wide, deep groove. This is the nether stone of John Bartram's cider-mill. The Botanic Garden remained in the possession of Colonel Carr till about 1850, when it became the property of Mr. A. M. Eastwick. This gentleman had derived much pleas-

ure from visiting the garden as a boy, and was resolved to preserve it without the sacrifice of a tree or a shrub. In 1853 a Handbook of Ornamental Trees, by Mr. Thomas Meehan, was published, the main purpose of which, as stated in its preface, was to describe the trees then in the Bartram garden. After Mr. Eastwick's death, the fate of the garden was for some time dubious. His executors saw no duty but to get as much money out of the estate as possible. About 1880 Prof. C. S. Sargent, of Harvard University, obtained the promise of a private subscription to buy the old garden, and a price was agreed upon, but the executors withdrew from the agreement. In 1882 Mr. Thomas Meehan became a member of the Common Councils of Philadelphia and at once introduced a scheme for small parks for the city, in which the Bartram place was included. Repeated reelections enabled him to follow the matter up, and finally, in the spring of 1891, the city took possession of the property, and put a superintendent in charge of it. The great gale of September, 1875, and some fifteen years of neglect had had their effect among the trees, but many planted by the botanist's own hands yet remain. It should be a source of gratification to all cultivators of science that this relic of the beginnings of botany in America is now assured of preservation.

Mr. W. W. Rockhill was credibly assured during his travels in Thibet that wild men were to be found in the eastern part of that country. His informant, a Mongol who had accompanied a Chinese trader in quest of rhubarb, described these savages as covered with long hair, standing erect, and making tracks like men. The author is of the opinion that they were nothing but bears; but he acknowledges that intelligent and educated Chinese, well acquainted with the appearance and habits of bears, believe that primitive savages are to be found in the Thibetan mountains; and he himself speaks of a forest fire in the Horpa country having driven out of the woods a number of hairy wild men, clad in skins and speaking an incomprehensible language. The Indian traveler Kishen Singh and Lieutenant Kreitner testify to the existence of wild men in those parts, and the former minutely describes them and their habits. It is curious, too, the Athenæum remarks, that the habitat of the wild man, whose progenitors may easily have relapsed into savagery, owing to the exceptional sterility and inaccessibility of northern Thibet and its adjacent deserts, should be the same as that of the wild camel and the wild horse, which there is good reason to believe are the prototypes of the domesticated varieties.

Mr. E. H. Man says that the little island of Chowry has for generations enjoyed the monopoly of pottery manufacture in the Nicobars. The work of preparing the clay and of molding and firing the finished vessel devolves on the female members of the community. The inhabitants of the island seem to guard their art jealously, and the value of trade-marks is recognized. No vessels are made especially by the Nicobarese for funeral purposes, but cooking-pots are among the personal and household articles that are laid on a grave after an interment. The people have no knowledge of anything like the potter's wheel.

CORRESPONDENCE.

THE WAYS OF BEES.

Editor Popular Science Monthly:

DEAR SIR: I have read Prof. E. P. Evans's article, on Progress in Lower Animals, in your December number, and it seems to me that some of the statements found therein call for the attention of a practical apiarist.

If all of them have no more foundation in fact than have those relating to bees, they furnish a very flimsy support upon which to found any kind of an argument.

I am well aware that there is a good deal of nonsense written in the name of science; but I do not remember having seen so many misrepresentations of facts, in the same length of space, in any article I ever read.

The professor says: "Beehives which suffer from overproduction rear a queen and send forth with her a swarm of emigrants to colonize, and the relations of the mother-hive to her colonies are known" (by whom?) "to be much closer and more cordial than those which she sustains to apian communities with which she has no genetic connection. Here the ties of kinship are as strongly and clearly recognized as they are between consanguineous tribes of men."

It is true that bees rear queens and swarm, but they do not rear a queen to send forth with a "swarm of emigrants"; for the young queen is not out of her cell until the old queen, her mother, is out of the hive and gone with the new colony. The "ties of kinship" are such that, should the young queen issue from her cell before the old one leaves the hive, she would usually receive a fatal sting from her mother, notwithstanding her "genetic connection," whatever that may mean. And the first young queen that gains her liberty is apt to treat her younger sisters in the same way, even before they have issued from their cells.

That the swarm after it has become settled in its new home recognizes in any way the relationship it bears to the old colony is utterly absurd, and, as every practical apiarist knows, has no foundation in fact.

The "ties of kinship" are not as "clearly recognized as they are between consanguineous tribes of men." Nay, the very opposite is true. They are not recognized at all after the swarm has become distinct and separate from the colony remaining in the hive, which is composed of the young bees with the young queen.

We are again told, "Bees readily substitute oatmeal for pollen, if they can get it." Bees can be taught to take *rye*-meal as a substitute for pollen when they can not get pollen, but neither Prof. Evans nor any one else ever saw a colony of bees that would take "*oatmeal*" in preference to pollen. In fact, they will not take *rye*-meal at all, if they can get pollen.

However, the above quotations are not so bad as they might be, for they are harmless—that is, it will do no more injury for the people to receive them as true than it would for them to receive any other innocent absurdity in the name of science. Had it not been for the statement which follows, I should not have felt called upon to point out these mistakes of the professor. But, in further support of his argument, he tells his readers that "apiarists now provide their hives with artificial combs for the storage of honey, and the bees seem glad to be relieved from making cells, as their predecessors had done." Apiarists do not "provide their hives with artificial combs," but they do sometimes fill the frames of their hives with comb foundation; but this is the *real stuff*—beeswax—in thin sheets with an imprint corresponding to the cells. This is not "artificial comb," and the bees are not "relieved from making cells." They have the cells to build, the same as they do when they secrete the wax in their own bodies, out of which the combs are formed. The modern apiarist furnishes the wax, and saves the time and labor of the bees that would be required to secrete it; but nothing but wax will do, and some colony of bees had to secrete that wax. It can not be made by any "artificial" process.

I hardly think that there is any evidence that the bees are "glad" to get this wax. We only know that they will use it.

Some years ago Prof. Wiley wrote what he afterward called a "scientific pleasantry" for The Popular Science Monthly, if I am correct, in which he described how "artificial comb" was made and filled with imitation honey, and declared that an expert could not distinguish it from the genuine stuff. He thus gave currency to what has become known among apiarists as the "Wiley lie," of which Prof. Evans's statement seems to be an echo.

You have no idea, Mr. Editor, how much injury this little "pleasantry" has done the bee-keepers of this land. For, notwithstanding the fact that Prof. Wiley has explained, over his own signature, that this was only a joke, and A. I. Root, of Medina, Ohio, has offered one thousand dollars for a single pound of the comb, which has not been forthcoming, yet the papers and the people go on repeating this slander on an honest and reputable industry.

I have no idea that Prof. Evans thought that he was doing any industry an injury when he wrote the article referred to; but it does seem that it is high time that people who write in the name of science about bees should inform themselves as to the facts, which may be obtained from any practical and intelligent apiarist, one or more of whom may be found in almost every community.

Very truly, EMERSON T. ABBOTT.

ST. JOSEPH, MO., *December* 18, 1891.

PROFESSOR EVANS'S REPLY.

Editor Popular Science Monthly:

SIR: In reply to Mr. Abbott's strictures I may state in general that all accounts of the habits of animals contained in my paper, so far as they are not the results of my own observations, are based upon the very best authorities. In my rejoinder I shall leave my critic in the undisturbed enjoyment of his consciousness of superior knowledge, and confine myself strictly to the points at issue. I was perfectly well aware, before Mr. Abbott informed me of the fact, that the old queen goes off with the swarm before her successor is permitted to come out of the cell, and regret that in expressing myself too concisely my words convey an impression which any one who has observed bees or read Huber knows to be incorrect. For the purpose I had in view and the point I wished to illustrate it makes no difference whether the old or young queen leaves the hive; and, as I had this point wholly in mind, I did not state the minor fact as accurately as I ought to have done. In my paper nothing is said of cordial relations between the two queens; I fear Mr. Abbott is indulging here in one of those "pleasantries," which facetious gentlemen in that part of the country seem to be addicted to, when they write about such funny creatures as bees. What I mentioned was the closer and more cordial relations observed to exist between bee-communities which have a genetic connection, or (as this phrase appears to puzzle Mr. Abbott) we will say between the mother-hive and its colonies. By whom has this been observed? Among others by Lenz, "a practical apiarist," and, what is more, a careful scientific observer, who kept bees, not merely to supply the market with honey, but chiefly in order to study their habits. The existence of such a relationship is recognized and referred to as a fact by no less an authority than Prof. Wilhelm Wundt, who even suggests that the mother-hive and its colonies may form a sort of federation. It is somewhat arrogant, even in a practical apiarist, to denounce any statement as "utterly absurd," and to declare that it "has no foundation in fact," simply because it has not come under his own observation. I did not assert that bees "take oatmeal in preference to pollen," but that they "readily substitute oatmeal for pollen;" and, in remarking that they are "glad" to be relieved of the extra labor imposed upon former generations of bees, I reasoned perhaps rather recklessly from human analogy, and imagined them feeling as men would do under the same circumstances. Mr. Abbott insists upon it that they are sorry; if so, I am sincerely sorry for them, and would fain think of them as glad; but the practical apiarist is inexorable, and I must console myself with the reflection that we really know nothing of the state of their minds. Mr. Abbott says it is rye-meal; a German *Bienenzeitung* says oatmeal (*Hafermehl*). So far as my argument is concerned, it may be rye or oats, or "it may chance of wheat or of some other grain."

We now come to the most serious offence, and indeed the only one that seems to have constrained Mr. Abbott to wield his pen in defense of a maligned and maltreated industry. I have asserted that "apiarists now provide their hives with artificial comb." Whether Prof. Wiley is the author of this statement or not I do not know, but I read it in an American scientific journal, with a full description of the manner of using it, how by revolving movement the honey is thrown out of the comb, and that the bees adapt themselves easily to the new arrangement. The interesting information was quoted by European journals of high standing; although one German paper suggested, rather maliciously as I thought, that the Yankees are a cunning folk, wonderfully productive of strange inventions, including all sorts of *canards*. Mr. Abbott now states that Prof. Wiley has explained over his own signature that his communication was only a "scientific pleasantry," a euphemism for what persons endowed with a finer moral sense call by a shorter and harsher name. But how are scientists in a foreign land three thousand miles away to know that an American professor has written, to a local paper perhaps, confessing that he is a liar, and that henceforth no one is to believe what he says? As for myself, I must acknowledge that I never before heard the statement contradicted, and I fully share Mr. Abbott's indignation against Prof. Wiley for deliberately fabricating and disseminating such a falsehood. A man so jocularly disposed and ethically slack-twisted should stop writing on scientific subjects and devote his talents as a professional "funny man" to the comical column of a country newspaper.

How artificial comb, if it could be fabricated and the bees should store it, would do injury to the bee-industry, I am at a loss to understand. In Switzerland, where honey is found on the breakfast-table in every inn, at least three fourths of it is artificial honey; and one proprietor of a large hotel recently admitted that he did not have a jar of real honey in the house. Real honey in an artificial comb is certainly preferable to manu-

factured honey that has never been in any kind of comb, but is sold in pots. Under the circumstances it seems to be rather gratuitous indignation to resent such a statement as a "slander on an honest and reputable industry."

All specialists are exceedingly sensitive to whatever touches their hobby, and unwilling to admit that they do not know all that is known about it. A few weeks ago a young archæologist called on a distinguished professor of classical archæology in a German university and stated that he was about to publish a work on a certain kind of Grecian vase. "There are no such vases," retorted the old professor. "But I have quite a collection of them which I have myself excavated," urged the young man. "They are all falsifications," was the terse and decisive answer. The simple fact was, that the old professor had never seen any vases of this sort. Rearing bees is not only a useful business, but also a fascinating study. If carried on as a specialty it suffers from the vice of all hobbies; even the practical apiarist, who hangs around hives all his life, is apt to have "a bee in his bonnet."

Yours, etc., E. P. EVANS.

REMARKABLE GLACIAL GROOVINGS.

Editor Popular Science Monthly:

SIR: Several references to the fine deep glacial groovings in the rocks at Kelley's Island, Ohio, have appeared in The Popular Science Monthly, and there also appear mentions of the commendable efforts of scientifically inclined gentlemen to purchase the land and dedicate it to public uses and preservation.

There are other places where the same action should be had, among them the groovings at Watertown, N. Y., uncovered and seen where an ancient glacial stream crosses Black River. The writer has crossed the continent four times upon different routes, and observed many places where glaciation has done its work, but in no place has he observed more unique and characteristic groovings than at Watertown. Lying in one of these grooves, several feet deep, may be seen immense bowlders weighing fifty tons or more, just where a glacier stranded and dropped its burden, showing as plainly how the grooving has been done as a plow standing in the furrow where some plowman had left it would tell its story.

The field notes of the Geological Survey of New York suggest that the river at some time has deserted its channel and eroded a new one from Watertown to Black River Bay, but this is not the case; the present channel is undoubtedly the original. At the date of the survey, glaciation and its work had not been much studied; the geologist mistook glacial erosion for earlier river erosion.

Another interesting point is the fact that the present river has eroded its channel some three feet deeper since the glacial era in the hard, heavy-bedded, and sometimes flinty bird's-eye limestone.

The glacial groovings at Kelley's Island and at Watertown may both be referred to the Adirondack Glacial period, belonging to the same age and agencies. The St. Lawrence River was then blocked with ice, and turned back upon itself, emptying its floods into the Ohio River.

Visitors may find these groovings both above and below the railroad bridge of the Cape Vincent track. D. S. MARVIN.

EDITOR'S TABLE.

THE ATTACK ON INTELLECTUAL LIBERTY IN GERMANY.

A THING which most certainly no one not supernaturally illuminated would have predicted has come to pass in Germany. A young man of thirty, who considers himself at once the father and the master of the German people, has intimated his good pleasure that every child in the German Empire shall have a theological education. It matters not what the parents of the children think; it matters not what the great body of the teachers think: his Majesty has made up his very mature mind, and all other minds must bow willingly or unwillingly to his decision. It is quite possible that, before the words we are now writing can appear in print, the imperial dictator may have seen the error of his ways, and may have concluded not to try the patience and self-respect of his subjects too far: none the less will it remain a notable fact that the possibility of fettering the German intellect in the most arbitrary manner should have occurred to a ruler of the German people in the very last years of the nineteenth century. We can not but argue ill for the future of a man

possessed of such overweening self-confidence. The ancient Greeks looked upon a character of this kind as probably predestined by the gods to a tragic end; and the experience of mankind has, on the whole, tended to show that their presentiment in such cases was not without foundation. Courage we admire, fidelity to principle we admire, resolute statesmanship we admire; but the determination of one man to impose his will upon a nation resembles madness rather than the exercise of any noble quality. It is hard for us in America to conceive how such a dream could have entered the head of any presumably sane man.

It is worth while, perhaps, to take this opportunity of asking the question why it is thought so very necessary to make special provision by law for the teaching of theological doctrines. The question is just as pertinent in this country as in any other; for there are many here who think such provision should be made, and who, if they could command a majority of votes for the purpose, would quickly make it. Only one answer can be given, and that is that the feeling of the promoters of such legislation is, that unless the doctrines in which they are interested are arbitrarily and compulsorily taught, they will have no chance of obtaining a lodgment in the minds of the rising generation. Faith in the home as a center of religious teaching seems to have almost wholly died out, and faith in the Church to be nearly as low; consequently the state is asked to step in and take up the task of inculcating the cardinal doctrines of Christian theology. As we pointed out last month, however, the inability of the state to do anything of the kind is an accepted conclusion with nearly all intelligent observers of the events of the time. What we may now further point out is that, were the state to attempt it, its success would mean before long the intellectual and even religious atrophy of the nation. Imagine for one moment the success of Emperor William's attempt. In twenty or thirty years the great bulk of the adult population would have gone through the official theological mill. All intellects would have been bowed to the official explanation—unanswerable because official—of the being and attributes of God. All would have bowed to the official proofs of the immortality of the soul. All would have accepted the official indorsement of ecclesiastical miracles, and the official interpretation of church history. All would have adjusted themselves to the principal historic creeds. No doubt some would have been brought up as Protestants, and some as Catholics; but as in each case the teaching was official, the effect would probably be to create a kind of imbecile readiness to admit as equally true the most contradictory positions. It is impossible, we maintain, for any person capable of reflection not to see that such a system of education would mean the death of all personal interest in, or apprehension of, the truths or doctrines inculcated. The being of God can not be proved in the same manner as the laws of chemistry; the latter admit of demonstrative proof, nobody asks for more than demonstration, and so long as demonstration is reached no one objects to the road by which it is reached; the former does not admit of demonstrative proof in the same sense, and everything depends upon the way in which such proofs as it does admit of are presented. Official teachers would, however, have to put forward their official proofs as demonstrative, and the effect would either be to deaden intellects or to turn out hypocrites by the thousand. The one and only guarantee for the vitality of theological beliefs is perfect freedom on the part of those who teach them and equal freedom on the part of those who learn them. Give to the individual intellect an infinite outlook upon the great problems of existence, and a reverential acceptance of

the cardinal principles of religion may well be evoked; but insist that definite answers must be found to these transcendent questions, and that there is just one authorized way of arriving at such answers, and you provoke revolt. The only result, therefore, of Emperor William's scheme, could it be realized, would be to fill the German fatherland with intellectual stagnation, formalism, and hypocrisy. Such, too, would be the effect here if the faint-hearts of the religious world could have their way. They would intrust the inculcation of religious truths to the public-school teachers, and would place religion on a par with geography, with this difference in favor of geography that it could prove all its statements by irrefragable evidence, while religion, though taught with an equal air of authority, could not in any similar manner prove its statements. Truly, the friends of a cause are often its greatest enemies, while those who get the credit of being its enemies are often its truest friends.

That the American people will not hand over their religion to the state to be sterilized in the public schools is now a matter of certainty, and it will be a very bad sign if anything of this kind happens in Germany. We can imagine a cynical enemy of all religion aiding and abetting the emperor's scheme, in the confident expectation that it would do more in ten years to extinguish vital religion in the German Empire than all the attacks of all the freethinkers could do in a century. We could imagine, too, that people with whom religion was a mere fashion or social badge might favor it as tending to attach a stigma to independent thought; but we can not imagine sincerely and intelligently religious people lending it any countenance. If the religious clauses of the present German education bill become law, it will be a clear sign that, to all intents and purposes, religion is dead in Germany.

SAFEGUARDS OF HEALTH.

WHILE disease at one front of battle is ever yielding to the advances of medical skill, at another it is as surely surrendering to the progress of hygiene. To-day the physician is asked not only how the sick may be healed, but how the well may stay well. From year to year investigation lengthens the list of diseases strictly preventable, and diphtheria and typhoid only linger to mark the neglect of well-understood precautions. Vaccination has been so striking an example of what prophylaxis can do, that hundreds of eager experimenters are endeavoring to bring consumption and scarlet fever into the same category as small-pox. From maladies less serious, but much more common, the public is fast learning that immunity is largely a question of taking care of one's general health and vigor. Seeds of disease which find a foothold in an enfeebled frame are either repelled by a sound and hearty constitution or harmlessly digested by it. To maintain this happy condition wholesome food, abundant exercise, personal cleanliness, temperance in all things, and the avoidance of worry are indispensable.

There are a good many people who know their lung-tissues to be delicate, or their heart-action to be irregular, or who suffer from some other constitutional weakness. Among this class the custom is gradually spreading of consulting a physician, not when acute difficulty has arisen, but as soon as the infirmity is detected, and periodically thereafter. Not seldom health is maintained in this way and life lengthened, for it is in their early stages of development that many diseases, especially the obscure derangements of the nervous system, can be most successfully treated. Perhaps it is the daily glass of spirits, or the weekly supper party, which the physician interdicts. Quite as often it is the allurement of the stock exchange or the card-table which he has to pro-

hibit. Whatever his advice, it has incalculably more value in preventing a crisis than in dealing with it after it has come to pass. Just as the best services of the lawyer are not in advocacy so much as in steering his client clear of the courts, so the doctor finds his worthiest skill to be in keeping his patient free from the need of cure or healing.

In the task of maintaining healthful conditions, general and special, a science has grown up in which not only the physician but the architect, the sanitary engineer, the purveyor of food and drink, the manufacturer of clothing, have deep interests. This great science of hygiene is now worthily represented in the University of Pennsylvania by a special laboratory devoted to it, which was formally opened on February 22d. It has been planned by Dr. John S. Billings, who is its director. The means for carrying it on are to be credited to the liberality of citizens of Philadelphia. The laboratory contains research rooms for investigations upon air, water, food, soil, and clothing; work-shops and photomicrographic rooms, and special arrangements for demonstrating the principles and practice of heating and ventilation, and of house drainage. In addition there are ample laboratories for chemical and bacteriological research. The course of instruction embraces the whole range of sanitary science—the disposal of refuse, the management of contagious diseases, the offensive and dangerous trades, methods of vital statistics, and sanitary jurisprudence. In directing this important work Dr. Billings is assisted by Dr. A. C. Abbott, recently Assistant in Bacteriology and Hygiene at Johns Hopkins University.

All honor to the men and women who have made this noble gift to their kind! It will mean joy and life to many thousands who else were doomed to hopeless suffering and premature death.

BOGY-HUNTING.

The British mind seems prone to conjure up terrors. The proposed tunnel under the Strait of Dover, whose importance to English commerce would probably equal that of all the docks of London, is made impossible by the affrighted query, What if the French should send an invading army against us under the sea? A display of this ludicrous apprehensiveness, of more special interest to cultivators of science, was given by The Spectator in an article on the celebration of Prof. Virchow's seventieth birthday. Is such public homage as Prof. Virchow received on this occasion, The Spectator asks, "good for science or good for the world in general?" Its fear is that unworthy persons will be drawn into the pursuit of science for the sake of the applause to be won therein, and it therefore looks askance at the dawning tendency to bestow merited praise upon the achievements of scientific men. The Spectator's ideal man of science—devoted to knowledge for its own sake, or rather for his own gratification, and wholly indifferent to the good opinion of others—is a rare and regretable phenomenon. The real man of science is a human being having the same warm sympathy with his fellow-men and the same need of their sympathy and appreciation that is found in the normally constituted man of any other calling. Shall a due measure of public esteem be denied to these men lest a few undeserving persons may try to share it? The services of scientific investigators have too long been repaid with proscription or neglect. Men whose occupation is the pursuit of truth know full well what justice is; and, if they are made to feel the smart of persistent injustice and the chill of unvarying loneliness, their capacity for work will be sure to suffer from these repressing influences.

But The Spectator has another apprehension, that rises to the dignity of a well-developed bogy. The aforesaid un-

worthy persons having been drawn into the pursuit of science, it apparently assumes that they would display sufficient ability in this field to make them very dangerous. Our bogy-hunter says:

> As a rule, science turns itself away from producing what is not useful but injurious, and concentrates its attention on what is likely to benefit mankind. It helps, of course, to make war inventions more effective, but no scientific man has yet persistently searched for means of destroying non-combatants wholesale, or for sterilizing vast tracts of country as a lava-flood sterilizes them. If once, however, the tone of scientific feeling is lowered, there is no knowing how far the maleficent side of science may be developed. . . . The results of scientific discoveries intended to be beneficial are often, as it is, turned to very ill uses. What would be the result if we had hundreds of active brains consciously attempting to shape Nature's actions to evil ends?

There is probably no career that is less likely to hold any unworthy persons who might be attracted to it than the pursuit of science. A sufficient command of chemistry, for instance, to enable a man "actuated by worldly motives" to produce "an air-poison so potent as to act instantaneously over a very wide area" can not be acquired except through an amount of patient research that no such person would endure. The Spectator had better sound its warnings where they are more needed. Take the field of literature, for example. Poets receive and have long received a vast deal more of adulation than has yet fallen to the lot of men of science. We like to think of poets as persons who can utter none but fine and noble thoughts. Is there not great danger that the ambitious youth may say of poetry what The Spectator imagines him saying of science, "Here is a field in which I can exchange my brains and my assiduity against popularity and worldly position with great advantage?" Would it not be better to withhold all marks of public esteem from poets than to risk having the craft adulterated with "persons primarily actuated by worldly motives"? Nor is this all. It is well known that poetry exerts a vast influence over the passions of men. The oft-quoted saying, "I care not who makes the laws of a people if I may make their songs," tersely attests this. What dreadful deeds a populace might be incited to "if half the [poets] were primarily anxious to sell their powers [of song] to the highest bidder!" Here, indeed, is a bogy by which The Spectator might well be terrified.

LITERARY NOTICES.

AFRICA AND AMERICA. By ALEX. CRUMMELL. Springfield, Mass.: Willey & Co. Pp. 466.

It is difficult to finish this volume of addresses without renewed interest in the condition and future of the African people. The author has not only studied the needs of the freedman in America, but through a residence of twenty years on the western coast of Africa has made himself acquainted with the Liberian colonists and many native negro tribes, and can differentiate the natural characteristics of his race from those acquired in years of bondage. He allows no rancor against those who have been its oppressors to obscure his judgment, and writes of slaveholders that they, "like all other sorts of men, were divided into two classes—the good and the bad."

Far worse than any present political injustice is the terrible inheritance of two hundred years of moral and intellectual degradation. To counteract this, an uplifting of character and industrial training are needed. The educational and material progress since emancipation disproves any idea of retrogression. According to the census of 1880, the colored population was assessed for over $91,000,000 of taxable property, and nearly 16,000 school-teachers were credited to them.

The race problem can not be settled by amalgamation nor by absorption. It is not a social question, but one of civil and political equality. Unless this is conferred upon the negro, the democratic idea is a failure. The trend of national affairs, however, is toward a fuller realization of justice, and the dwelling together of various races in amity.

Several papers treat of the condition of

the negro in America; others relate to the interests of Liberia; the Congo State; the aims of education and the lives of noted leaders. All are well thought out, and can not fail to be helpful to the people for whom they were written.

ESSAYS UPON HEREDITY AND KINDRED BIOLOGICAL PROBLEMS By AUGUST WEISMANN. Vol. I. New York: Macmillan & Co. Pp. 471. Price, $2.

THE three great names in the history of biologic evolution are those of Lamarck, Darwin, and Weismann. The first edition of this work, which was soon exhausted, appeared as a single volume, and at a much higher price. The present volume is more desirable, as one gets with it a list of references to the numerous discussions that its appearance immediately evoked, and which has continued at a high tension and without interruption in the numbers of Nature and other periodicals ever since. One can understand the cause of the intense feeling shown in these discussions by glancing at the titles of these essays which have appeared at various times since 1881: The Duration of Life, 1881; On Heredity, 1883; Life and Death, 1883; The Continuity of the Germ-plasm as the Foundation of a Theory of Heredity, 1885; The Significance of Sexual Reproduction in the Theory of Natural Selection, 1886; On the Number of Polar Bodies and their Significance in Heredity, 1887; On the Supposed Botanical Proofs of the Transmission of Acquired Characters, 1888; and The Supposed Transmission of Mutilations, 1888.

While any one of these subjects was sufficient to excite endless controversy, the last two essays were bound to bring on an irreconcilable conflict. A principle that we had regarded as settled, namely, that traits acquired by the individual during life could be transmitted to his offspring, is not only denied by Weismann, but this corner-stone of natural selection being knocked away, the edifice, to our astonishment, does not tumble, but remains just as steady without it. The author's judicial and temperate way, his admission of doubt, where doubt exists, inspires confidence in his deductions. In ending his essay on the Duration of Life, he says: "And so, in discussing this question of life and death, we come at last—as in all provinces of human research—upon problems which appear to us to be, at least for the present, insoluble. In fact, it is the quest after perfected truth, not its possession, that falls to our lot, that gladdens us, fills up the measure of our life, nay! hallows it."

In closing his essay on Life and Death he says: "Life is continuous, and not periodically interrupted: ever since its first appearance upon the earth, in the lowest organisms, it has continued without break; the forms in which it is manifested have alone undergone change. Every individual alive to-day—even the very highest—is to be derived in an unbroken line from the first and lowest forms."

It is impossible within the limits of a brief review to make even an abstract of the writer's arguments. The low price of the work enables every student to possess it. To the few remaining opponents of evolution among thoughtful students who are unfamiliar with the facts and details cited, this hot discussion between the Weismannians and the Neo-Lamarckians must seem fratricidal, whereas it may be compared to a band of earnest travelers perfectly united in their efforts to reach the same goal, and, coming to a number of cross-roads, heatedly discuss which is the right road, firmly resolved to follow that when demonstrated, even if many have to finally retrace their steps in order to do so. The acrimony and satire which have been excited by these discussions are in consequence of the fact that there is no half-way ground upon which the combatants can unite. It must end in absolute defeat to one or the other side. Great credit is due to Edward B. Poulton, Selmar Schönland, and Arthur E. Shipley, all accomplished biologists, for their connection with the work as editors.

THE STORY OF THE HILLS. By Rev. H. N. HUTCHINSON. New York and London: Macmillan & Co. Pp. 357. Price, $1.50.

THE simple description on the title-page of this work—"a book about mountains for general readers"—aptly characterizes the contents and style of the volume. The author has written especially for those who enjoy mountain scenery, and has aimed to heighten their enjoyment by increasing their understanding of what they see. He has

not, however, put so strong an infusion of science into the book as to make it distasteful to those who read chiefly for pleasure. The first part of the book is descriptive, dealing with "the mountains as they are," and in the latter part is told "how the mountains were made." Throughout the volume are scattered bits of picturesque description quoted from enthusiastic lovers of mountains, illustrative anecdotes, and fragments of verse. The style is every where clear, and the language is simple, few terms being employed that are not in the vocabulary of every cultivated person. The text is illustrated with sixteen full-page pictures from photographs by W. Donkin, J. Valentine, and others. The Story of the Hills will add much to the reputation which the author has gained through his Autobiography of the Earth.

GEOLOGICAL SKETCHES AT HOME AND ABROAD. By ARCHIBALD GEIKIE. New York: Macmillan & Co. Pp. 332. Price, $1.50.

THESE fourteen papers consist of popular accounts of geological explorations, with a few essays and addresses on geological subjects. Several of them have been thought of sufficient general interest for publication in the popular periodicals Good Words and Macmillan's Magazine. The first of these sketches describes the author's earliest geological excursion, and contains some striking testimony as to how science was taught when Prof. Geikie was a boy. Other papers describe excursions in Scotland, France, Norway, the Yellowstone Park, and Wyoming. The text is illustrated with views of many of the places visited, and with geological diagrams.

SCHOOL AND COLLEGE. Edited by RAY GREENE HULING. Monthly. Boston: Ginn & Co. Price, $1.50 a year.

THE first number of an educational magazine with the above name appeared in January. It starts as a periodical of high grade, under the editorship of the principal of the high school at New Bedford, Mass., who is well known as an educator and a writer on educational topics. The opening article of the January number is by E. Benjamin Andrews, President of Brown University, on Some of the Next Steps forward in Education, and is characterized by a fullness of progressive spirit. James H. Blodgett, of the Census Office, contributes a statistical paper on Secondary Education in Census Years. There is a descriptive article on The Greek Method of performing Arithmetical Operations, by John Tetlow, head master of the Girls' High and Latin Schools, of Boston, which is illustrated with diagrams. B. C. Burt, of Ann Arbor, discusses the question When should the Study of Philosophy begin? There is also an editorial department, in which Co-operation in Entrance Examinations and Compulsory Greek in England are discussed; departments of News from Abroad, and Home News, the latter containing statistics of college attendance in 1890–'91; also departments for Letters and Reviews.

STAR-LAND. By Sir ROBERT STAWELL BALL, F. R. S. New York: Cassell & Co. Pp. 388.

THE Royal Institution of Great Britain provides at each Christmas season a course of juvenile lectures. In 1881, and again in 1887, the course was given by the Royal Astronomer of Ireland, who has embodied his lectures in the present volume. The several lectures deal with the sun, the moon, the inner planets, the giant planets, comets and shooting-stars, stars, and to these has been added a chapter, with the title How to name the Stars, telling how to recognize the constellations. Since the lectures were prepared for an audience of children, their style is simple, though not childish, and many adults could get a better understanding of the outlines of astronomy from this little book than from more dignified treatises. The text is illustrated with nearly a hundred pictures.

THE MICROSCOPE AND ITS REVELATIONS. By the late WILLIAM B. CARPENTER, M. D., F. R. S. Seventh edition. Revised by W. H. DALLINGER, F. R. S. Philadelphia: P. Blakiston, Son & Co. Pp. 1117.

THE great advances in the application of mathematical optics to the construction of microscopes since the appearance of the sixth edition of this cyclopedic work have made necessary a recasting of a large part of the treatise. The editor states in the preface, somewhat paradoxically, that the first five chapters of the last edition are rep-

resented in this one by seven chapters, two of which "are on subjects not treated in any former edition." In the second chapter, on the Principles and Theory of Vision with the Compound Microscope, the results of the past twenty years' labors of Dr. Abbe, of Jena, have been summarized in a manner that has received Dr. Abbe's hearty commendation. In treating many of the other topics Dr. Dallinger has had the aid of eminent specialists. The book is increased by two hundred and fifty pages over the size of the last edition. Great pains have been taken to bring the text up to the most recent knowledge of experts, and the illustrations have been increased by the addition of nineteen new plates, many being colored, and three hundred woodcuts, making the whole number over eight hundred.

THE PHOSPHATES OF AMERICA. By FRANCIS WYATT. New York: The Scientific Publishing Company. Pp. 187. Price, $4.

THE best evidence of the usefulness of this book is that a second edition was required within a week from the publication of the first. After setting forth the value of phosphates in producing fertility of soils, the author describes in successive chapters the deposits of phosphates and the modes of mining them employed in Canada, South Carolina, and Florida. Lists of companies engaged in phosphate-mining, with their capitalization, are given, also the expenses of working, the equipment required, and the selling prices of the products. These chapters are illustrated with many views of mines, drying-sheds, and machinery for handling and treating the ores. The manufacture of sulphuric acid is then described, after which the making of superphosphates is treated, and a final chapter contains methods of analysis of the materials and products of these manufactures. The author states that the volume embodies many facts, figures, and suggestions resulting from long observation and an extremely varied practical experience, and he trusts that it will prove highly profitable to all classes of persons interested in the production, manufacture, sale, and consumption of commercial fertilizers. He has aimed to couch the information in common language, avoiding, as far as possible, chemical formulas and technical terms.

The first volume of a monograph on *The Tannins* has been published by Prof. *Henry Trimble* (Lippincott, $2). It contains chapters on the discovery, general characters, and the detection and estimation of tannins, followed by a detailed treatment of gallotannic acid. An index of authors, an index, or more properly a chronological table, of the literature of tannin, and a general index to the volume, are appended.

The *Experiments arranged for Students in General Chemistry*, by Profs. *Edgar F. Smith* and *Harry F. Keller* (Blakiston), has reached a second and enlarged edition. It is adapted to beginners, and is not intended to displace the instructor, but rather to assist him. References are made to Richter's Inorganic Chemistry, but any other suitable book may be used instead. Thirty-seven diagrams of apparatus are given, and questions and problems are interspersed throughout the directions for experiments. The volume is interleaved with blank leaves for notes.

Radical Wrongs in the Precepts and Practices of Civilized Man, by *J. Wilson* (the author, Newark, N. J., $1), is devoted to condemning practices of modern social life that, in the opinion of the author, are wrong. Mr. Wilson denounces war, cruelty to animals, capital punishment, private ownership of land, taking payment for the use of money, disposing of property by will, etc., with equal emphasis.

The second volume of the exposition of the *Hermetic Philosophy*, by an editor who signs himself in an enigma (*Styx, of the "H. B. of L."*), is published by the J. B. Lippincott Company, Philadelphia ($1). The work as a whole includes lessons, general discourses, and explications of "fragments" from the schools of Egypt, Chaldea, Greece, Italy, Scandinavia, etc., designed for students of the Hermetic, Pythagorean, and Platonic sciences, and Western occultism. The present volume contains the second lesson on the Principles and Elements of Things, and a discourse from Porphyry on Auxiliaries to the Perception of Intelligible Nature. The introduction comprises a notice of Sanchoniathon, the ancient Phœnician philosopher and historian, and the text of the fragment of his Cosmogony and Theogony which has been preserved by Eusebius; and the dis-

course by Porphyry is preceded by a notice of that writer.

Mr. *Andrew J. Rickoff*, in preparing the *First Lessons in Arithmetic* (American Book Company, price, 36 cents), has endeavored to promote clear, accurate, and thorough work in the four fundamental rules and the training of the judgment in the proper application of those powers. It is divided into three parts, of which the first is devoted to exercises—each number being studied in all combinations—in numbers not greater than ten. All the processes are graphically illustrated with diagrams arranged so as to resemble the dots on dominoes. Part II deals with units and tens, with the graphic method continued. After the study of the number fifty, equal parts—halves, fourths, and eighths—are considered. Familiar measures are introduced. In Part III the treatment of numbers up to one hundred is completed, the pupil is carried through the four fundamental rules in the higher orders, and is familiarized with their application to simple business transactions. No abstract reasoning or intricate problems are introduced. Training to reckon rapidly and accurately is mainly sought, and the book is intended to systematize and facilitate rather than to supersede oral instruction.

A useful manual of *Cookery for the Diabetic* has been prepared by *W. H.* and *Mrs. Poole*, and is published by Longmans, Green & Co. (price, $1). In explanation of its purpose Dr. F. W. Pavy says, in a preface which he has written for it, that it is necessary to frame the dietary in diabetes so as to exclude as far as practicable certain principles of food which enter considerably into the dietary of ordinary persons. The basis or material part of a dish placed upon the table may be permissible, but accessories introduced in the cooking of it may render it objectionable. Diabetics are often in this way deprived of many of the properties which render food palatable and attractive, and reduced to a monotony of a few dishes of the plainest character. Mr. and Mrs. Poole seek to relieve them from this inconvenience by furnishing them with recipes by which their food may be given pleasant seasoning and at the same time harmless to them, and its variety may be increased.

The distinctive features of the *Inductive Latin Primer* (American Book Company) of *William R. Harper* and *Isaac B. Burgess* are that the lessons are shorter than those of the Inductive Method of the same authors; formal grammar is reduced to a minimum, and is introduced more slowly; no reference is made to the grammar during the early lessons; the exercises are easy and copious; prominence is given to conversation upon the text; maps, plans, and pictures are introduced; and a treatment of English grammar, inductive in character and adapted to those who never studied English grammar before and to the needs of those studying Latin, is bound with the Latin lessons. The work is based upon the connected text of Cæsar.

Russian Traits and Terrors are vividly portrayed in a book of that name, which professes to be a faithful picture of the Russia of to-day; published by B. R. Tucker, Boston (35 cents). The author's name, if it can be called that, is *E. B. Lanin*, which we are told, however, is the collective signature of several writers in the Fortnightly Review. An unpleasant picture enough is given of lying, fatalism, sloth, and dishonesty as Russian characteristics; of the condition of Russian prisons; of a low stage of sexual morality; of the miserable situation of the Jews; of Russian finance, which is represented as a "racking of the peasantry." To all this is added an ode by Swinburne, written after reading the account of the prisons.

Homilies of Science (Open Court Company, Chicago) is a collection of papers on subjects related to religion, which were first contributed by the author, Dr. *Paul Carus*, as editorial articles in The Open Court. The principle that pervades the papers is to preach an ethics that is based upon truth and upon truth alone. The homilies are declared not hostile toward the established religions of traditional growth, but toward the dogmatic conception only of those religions. They are also not hostile toward free thought, but, standing upon the principle of avowing such truths alone as can be proved by science, they reject that kind of free thought only which refuses to recognize the authority of the moral law. The author accounts for his position on these matters by relating that in childhood he was a devout and pious Christian; on growing up, he re-

solved to be a missionary; studying for that, he lost his faith in dogmatic Christianity, but found his religious ideals purified, and became a missionary of a religion which knows no dogmas; which is not in conflict with Christianity; which can never come in conflict with science, and is not in conflict with any other religion; "for it is the goal and aim of all religions."

Very different from the reverential spirit of Dr. Carus's Homilies is the tone of Mr. *G. H. Martin's Antidotes for Superstition*, which comes to us from Watts & Co., London, and which we can only describe as a vehement attack on Christianity, its origins and purport. In the first chapter—on Christian Veracity—the charge is made that the method of teaching biblical history and chronology in the seminaries "is one of organized misrepresentation and systematic concealment of facts," and that the rest of Christian instruction is of the same kind. In the second chapter the essential spirit of Christianity is described as "a most malign, subtle, and Protean spirit." The assignment of other similar traits is followed by attempts to show, in Christianity before Christ and Pre-Christian Gospels, that what is good in Christianity is of more ancient origin and is common to pagan religions; and by "ammunition for our recruits" in the shape of supplied answers for persons unskilled in debate, to the arguments of the apologists for Christianity.

The *Commission of Fish and Fisheries* has issued the *Report of the Commission for 1887*, which covers the whole of that year and the first half of 1888. Future reports will cover the fiscal year of the Government instead of the calendar year, as heretofore. In the summer of 1887 occurred the death of Prof. Baird, who had been commissioner since 1871. The duties of the office were performed for about six months by Dr. G. Brown Goode, and the Hon. Marshall McDonald was then appointed commissioner. The work of the eighteen months covered by this volume is reviewed in the commissioner's report, and to it are appended an account of the Fisheries of the Great Lakes, by H. M. Smith, M. M. Snell, and J. W. Collins; a Report upon the Division of Fisheries, by J. W. Collins; reports on the distribution of fish and eggs by the commission, and on the work of the steamer Albatross; reports on the construction and equipment of the schooner Grampus, by J. W. Collins; on the operations of the Grampus, by J. W. and D. E. Collins; a Review of the Labroid Fishes of America and Europe, by David Starr Jordan; a paper on Lake Superior Entomostraca, by S. A. Forbes; and one on Entozoa of Marine Fishes of New England, by Edwin Linton. All these papers are fully illustrated.

The *Sixth Annual Report of the Commissioner of Labor*, being the report for 1890, is devoted to statistics of the cost of producing iron and steel. It makes a volume of fourteen hundred pages, and is divided into three parts, of which the first gives the cost of labor, raw materials, and other elements that enter into the total cost of production; the second is devoted to the time and earnings of laborers, and the efficiency of labor; while the third part, comprising eight hundred pages, shows the cost of the laborers' living, in detail. Establishments in Great Britain and on the continent of Europe, as well as in the United States, were included in the investigation. This is one of the reports on the cost of producing dutiable articles which are called for in the act of Congress establishing the Department of Labor, and throws a vast amount of light upon the question of how much protection the iron and steel industries need in order to continue the present wages of American workmen.

The fifth of the lists of special classes of novels, compiled by *W. M. Griswold*, is a *Descriptive List of British Novels* (the author, Cambridge, Mass., $2), comprising over nine hundred titles. Each entry is accompanied by from a few lines to half a page of description, which in most cases is taken from a review in some prominent literary periodical. We can join heartily with Mr Griswold in the hope that "the publication of this and similar lists will lessen, in some measure, the disposition to read an inferior *new* book when superior *old* books, equally fresh to most readers, are at hand." There are no antiquated books in the list before us—the oldest that we note are some of George Eliot's which appeared in 1859 and 1860. Surely no apology is needed for going back far enough to include these.

The Bacteriological World and Modern Medicine, formed by the fusion of the two journals whose united names it bears, issued the first number of its new series in November, 1891. It is edited by *Paul Paquin*, M. D., and *J. H. Kellogg*, M. D., with a large staff of collaborators (Battle Creek, Mich., $2 a year). Among the contents of the three numbers before us are continued articles on Influence of the Continuous Current on Microbes, by MM. Apostoli and Laguerrière, with illustrations; The Influence of Dress in producing the Physical Decadence of American Women, by J. H. Kellogg, M. D., illustrated with pneumographic tracings, outlines of natural and constricted forms, etc.; Lessons in Bacteriology, by Paul Paquin, M. D.; and The Application of the Microscope in Medical, Medico-legal, and Legal Difficulties, by Frederick Gaertner, M. D. There are also shorter articles, notes, reviews, editorials, etc. The journal has as a department the bulletins of the Medical and Surgical Sanitarium, and of the Laboratory of Hygiene connected with it. In addition to the other illustrations, each number contains one or two colored plates.

A *History of Circumcision* has been published by *P. C. Remondino*, M. D. (F. A. Davis, $1.25 and 50 cents), extending from the earliest times to the present. The author describes the Hebraic and other modes of performing this operation, and argues strongly in favor of the practice, setting forth a great many annoyances and diseases to which the presence of the prepuce contributes, both in early and in later life. The book contains also descriptions of infibulation, muzzling, and other operations that have been practiced on the prepuce, and histories of castration, eunuchism, hermaphrodism, and hypospadias. The work gives abundant evidence of having been carefully prepared, and can not fail to be of service to the surgeon. It contains much information, moreover, that would benefit lay readers, and the author's declared intention of making the volume "readable" has been very successfully carried out. Over a hundred notes to the text, a list of works quoted, and an index are appended; there are also two illustrations, one of Hebraic and the other of Egyptian circumcision.

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Black, George Ashton. History of Municipal Ownership of Land on Manhattan Island. New York: University Faculty of Political Science. Pp. 88, with Plates. 50 cents.

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POPULAR MISCELLANY.

The Peabody Museum of Archæology.—The Peabody Museum of American Archæology has received for current expenses since 1881, when the first gift was made to it, $27,801. The gifts amounted to an average of $3,089 a year. The permanent fund for the support of the museum gives an income of $2,376 a year. At no time has so much interest been taken in the work of the museum or in aid of its explorations as during the past two years. Important additions have been made to the building, and improvements in the arrangement of the collections. Among the results of the various works are additional discoveries of palæolithic implements in the Trenton gravel by Dr. Abbott, and of others from the older or Columbian gravel by Dr. Cresson; discoveries by Mr. Ernest Volk in relation to the early people of the Delaware Valley; explorations by the curator of burial-places of Massachusetts Indians at Winthrop; of Seneca Indians in the Genesee Valley; and of village sites of Indians in the Potomac Valley, with recovery of chipped stones and implements in various stages of manufacture from an ancient workshop. The Serpent Mound Park has been completed, and the hay crop and the discriminate cutting of timber from parts of the land will help bear the expense of maintaining it. A collection and several important objects have been received from Mexico, Yucatan, and Santo Domingo; crania of Zuñi and of a Tierra del Fuegian; the sacred pole of the Omaha Indians, with the scalps of noted enemies of the tribe, the sacred pipe, arrows, etc.; Peruvian pottery and pottery vessels, stone implements, and carved stones from Chiriqui; implements, weapons, masks, etc., from New Guinea and several islands of the Pacific; casts of M. Desiré Charnay's collections of the Lorillard Expedition to Yucatan and Mexico; and copper implements from the province of Tobasco, Mexico, which will form an important link in the chain of evidence upon the working of stone in Mexico and Central America. Continued explorations in the Little Miami Valley have resulted in the discovery of some ancient hearths half a mile below the Turner earthworks, which furnish evidence of the occupation of the bottom lands at different intervals during the formation of the deposit that fills the valley. The Turner earthwork has now been thoroughly explored; more so, perhaps, than any earthwork in the country. In the last mound examined, large flint points of peculiar shape, handles made of antlers, and specimens of the objects called gorgets made from a stalagmitic or fibrous gypsum, were found—all unique. Another curious work has been examined at Foster's, about twenty miles above the Turner group. It is a circumvallation more than half a mile in extent, made up of a carefully laid wall of flat stones, loose

stones behind it, and behind and over these a mass of clay burned to all degrees of hardness. The curator pronounces it one of the most remarkable structures he has ever seen. Lectures and instructions have been delivered on some of the subjects cherished by the museum, and an outline of a course of American archæology and ethnology for advanced students is published in the report. The most important of the later gifts is one by Mrs. Mary Copley Thaw, of Pittsburg, for a fellowship fund, of which Miss Alice C. Fletcher is to be the first beneficiary.

The Harvard Observatory Time-Service.—In giving notice of the discontinuance, after the end of March, of the time-service furnished by Harvard College Observatory, Prof. Pickering has taken occasion to give a brief history of the operation of this branch of the observatory's work. It has been maintained for nearly twenty years, and has given continuous signals—that is, signals throughout the twenty-four hours, instead of for a short time each day—to the cities of Boston and Cambridge, the railroads centering in Boston, and the Western Union Telegraph Company. Through the latter agencies the signals were distributed over a large part of New England and to New York city. The subscriptions of the city of Boston and the railroads, and the receipts from jewelers who timed their clocks by the signals, were sufficient to defray the cost of furnishing the exact time, and for some years formed a source of revenue to the observatory, while no charge was made to the city of Cambridge or the Western Union Telegraph Company. The observatory was one of the foremost and most earnest promoters of the adoption of standard time, although its revenues were likely to be diminished by it. One of the greatest advantages of the time-service to the observatory was that it kept before the public the practical value of astronomical work. Many thousands of persons, who take no interest in a work of a purely scientific character, realize the great financial value to the public of an accurate standard of time. The observatory desired to confer this benefit on the public, and would have been ready to do so, even at a financial loss; but recently the time signals of the United States Naval Observatory have been offered to the public at very low rates, through the Western Union Telegraph Company, and the Harvard College Observatory is relieved of the duty. The expense of furnishing the time is borne by the people through a Government appropriation. A time-service, under which the people at large within its sphere were supplied at the expense of a few who received special benefits from it, gives way to a system under which these special interests are supplied free by taxation of the whole people.

Preservation of Delicately Colored Specimens.—A mounting fluid for specimens compounded by Mr. Haly, of the Colombo Museum, Ceylon, proves to be also an excellent medium for preserving the colors of fish and other animals. It is composed of cocoanut oil and carbolic acid. The most tender frogs and snakes, the delicate plum-like bloom on the geckoes, the fugitive reddish tint on certain snakes, are not injured but are beautifully preserved by it. Preserved fish-skins can be packed away in it for an indefinite period, and, although they do not preserve their sheen like fish in the oil itself, they maintain a silvery and natural appearance, very different from that of ordinary museum specimens. It appears to be an excellent preservative for crustacea, the higher orders of arachnids and centipeds, but has hitherto proved a failure for marine invertebrates in general. The perfect miscibility of the two liquids opens up endless possibilities. The absolutely unevaporable nature of the liquid, apart from its other qualities, makes it invaluable in a tropical climate. The acid makes it possible to mix cocoanut oil and turpentine, and thus is formed a splendid microscopic fluid, in which objects may be allowed to soak, without any previous preparation, and in which they become very transparent.

Cultivation of the Bermuda Onion.—The Bermuda onion is raised, according to Mr. Russell Hastings, in Garden and Forest, in a temperature which from November to June ranges from 50° to 75°, never higher, never lower, with never a greater monthly range than 25°, or a greater daily range than 14°. Its value lies in its mild and delicate flavor,

as well as in the unusual season at which it is fresh. The seed is all grown in Teneriffe Island, of two varieties, one producing white and the other red bulbs. The white bulbs are a little earlier, but the red ones are sweeter. The seed is sown very thickly in seed-beds—the soil of which has been prepared with special care and highly enriched—from the last of September till early in November. The plants are transplanted in December and January. The fields are little pockets of earth scattered here and there over the island, in depressions between the rocks. They seldom contain an area of more than two acres, and the larger proportion of them contain less than half an acre. The soil is carefully prepared and laid out, by treading paths into beds about three feet wide, into which the little plants, about as large as a goose-quill, are transplanted from the seed-beds. The whole number of acres cultivated on the island of Bermuda in the winter of 1890–'91, in onions, potatoes, tomatoes, and beets, was 2,422.

Manufacture of Silk Gauzes.—Silk gauzes are manufactured by a special method distinct from all other modes of weaving, in which, according to M. G. Henneberg, of Zurich, the first consideration is the selection, from among the best brands of raw silk, that which will give the most uniform and the firmest twist. The twist is obtained by spinning two threads, one upon the other, about a thousand turns to the metre of length. When the threads intended for the chain have been stretched uniformly with the most delicate care, to prevent a premature wearing away (which occurs when the tension is unequal, by the two light threads snapping) each of the threads of the chain is passed separately between two meshes of the weaving harness, and between the teeth of the comb or of extremely fine steel. To show how carefully this work must be done, we mention that a steel comb used in weaving a gauze one metre wide, No. 17, has 6,517 teeth, with as many spaces between them. Next is the preparation of the chain for the operation of weaving, by moistening it with soft brushes. Some of the valleys of eastern Switzerland, on account of their elevated position and special climatic and atmospheric conditions, seem particularly well adapted to the weaving of a strong twist, exceptionally brittle and hard. The weavers do their work in couples or threes in specially constructed cellars abundantly lighted and aired, the temperature of which should be kept nearly the same—about 50° Fahr.—through the whole year, and the moisture seventy-five per cent. Whenever a notable variation in temperature takes place, the weaving should be stopped till a favorable change occurs. The weaver should be a strong, hearty man, because the management of the loom demands much skill and a more than ordinary toughness of body. When the piece is done, it is washed, stretched on a frame to dry, and dried by drawing a pan of hot coals back and forth under it. Silk gauze must be kept in perfectly dry and well-aired places.

Habits of the Wandering Albatross.—Of the wandering albatross (*Diomedea exulans*) a Mr. Harris, who has carefully studied it, says that at a certain time of the year, between February and June, the old birds leave their young and go to sea, not to return till October, when they arrive in large numbers. During their absence the young birds never leave the breeding-ground. Immediately after the return of the old birds, each pair goes to its old nest, and, after a little fondling of the young one, turns it out and prepares the nest for the next brood. The deserted young ones are in good condition and very lively, being frequently seen off their nests exercising their wings; and when the old birds come back, a young bird will often remain outside of the nest and nibble at the head of the old one, until the feathers between the beak and the eye are removed, and the skin is made sore. The young birds do not go far from land till the following year, when they accompany the older ones to sea.

Railway Accidents for 1889–'90.—According to the statistics of the Interstate Commerce Commission, the total number of passengers, employés, and other persons not trespassers, who suffered death or injury on railroads in the United States during the year ending June 30, 1890, was 29,196, of whom about five sixths were employés. The number of casualties to employés was greater by

2,845 than in 1888–'89, and greater by 2,627 than in 1887–'88. The number of casualties to passengers was 255 greater than in 1888–'89, and 258 greater than in 1887–'88. In each class the number killed is about one tenth of the number injured. The largest number of casualties occur to employés engaged directly in handling trains. Thus, while trainmen represent but 20 per cent of the total number of employés, the casualties sustained by them account for 58 per cent of total casualties. A passenger riding continuously at the rate of 30 miles an hour might expect immunity from death by railway accident for 158 years; but an engineer, a brakeman, or a conductor, under the same conditions, is liable to a fatal accident at the expiration of 35 years. The most common accident to which railway employés are liable results from coupling and uncoupling cars. Railway travel is found to be least safe in the States south of the Potomac and Ohio Rivers. In the Western territory railway employment and travel are slightly safer than in the Southern States, while the smallest proportion of accidents occur in the States east of Illinois and north of the Potomac and Ohio.

The Power of Water in Motion.—After an elaborate series of computations, Prof. Samuel B. Christy, of the University of California, concludes that if a nozzle of from six to nine inches diameter were specially arranged to throw a stream of water vertically upward against a spherical bowlder of quartz weighing 1,000 pounds, the vertical head being anywhere from 100 to 500 feet, the bowlder would be forced up until the diminished velocity of the stream established an equilibrium of pressures. There would be a point at which the upward pressure of the stream would exactly balance the gravity pressure of the bowlder, holding the rock suspended. In practice, of course, the bowlder could not be balanced accurately upon the axis of the stream, but would fall to one side or the other. But if a large conical basket of iron bars were arranged about the nozzle so as to catch the bowlder whenever it should be deflected from the stream, and return it to the nozzle, the 1,000 pounds of quartz would be kept in play like a ball in a fountain. As to cutting these streams, Prof. Christy says that he has often tried to drive a crowbar into one of them. The stream felt as solid as a bar of iron, and, although he could feel the point of the crowbar enter the water for perhaps half an inch, the bar was thrown forward with such force that it was almost impossible to retain it in the grasp. An axe swung by the most powerful man could not penetrate the stream; yet, it might be cut by the finger of a child, provided the child were seated in a railway train moving parallel with the stream in the same direction and with the same velocity, which would be considerably more than a mile per minute.

Chinese Roads.—According to a communication by the United States minister in Pekin, road-making has not been brought to great perfection among the Chinese. The country abounds in water-ways, and roads receive the less attention. Human carriers being cheaper than beasts of burden, the need of roads over the mountain passes is not so seriously felt as it otherwise would be. In southern China, at the centers of the tea trade, the long string of coolies bearing down from the hills the leaves, in deep baskets slung on poles, is a familiar sight. In northern China, where water-ways are not so numerous as in the south, intercommunication has always presented serious difficulties, which no attempt has been made to overcome. Bridges have been built over some smaller streams, but are not kept in repair. The large rivers are to be crossed by ferries only, the smaller ones to be forded. In some places there are bridges, too narrow to be crossed by carts, where the mules are taken out and led singly, while the carts are carried over on men's shoulders. In times of flood there is frequently no way of crossing. Intelligence is conveyed between the capital and outside provinces by an elaborate system of post stations thirty miles apart, where relays of horses are kept in readiness for the imperial courier. By these means dispatches have been sent to distant capitals at the rate of two hundred and fifty miles a day. The express courier from Gartok to Lhara, in Thibet, a distance of eight hundred miles, travels night and day, and is not relieved. His clothes are sealed on him, and can be removed only after the seal has

been broken by the proper official. The messengers are lifted at the post station from one horse to another, and sometimes die on the way from exposure and fatigue. Over some mountain roads, which would otherwise be impassable, considerable work has been done and money expended. In some places the paths have been paved for foot-passengers, and in others provision has been made for the passage of carts. Most of these roads date from very remote periods, but there are occasional instances of recent construction and repair.

Forest Growth after Fire.—In an article in Zoe, quoted in Garden and Forest, Mr. T. S. Brandagee describes the vegetation that grows on ground over which forest fires have run, particularly in Colorado, Montana, and on the Pacific coast. Trees have a power of resisting fire proportioned to the thickness of their bark. The redwood trees of the forests of the California coast, when they are killed or burned to the ground, send up new shoots from their roots, which soon surround the old stems with a luxuriant growth; the parent stem disappears in time, leaving only the circular groves characteristic of the redwood. The forests of Douglas fir in the coast region of Oregon and Washington destroyed by fire are in time replaced by countless seedlings which under favorable conditions grow very rapidly. The mountainous region is usually more commonly covered with a new growth than regions of lesser altitudes, although the new growth is not always at first the same as that of the original forest. Fire is very apt to destroy in the mountain regions the seeds of conifers, for seedlings do not appear immediately on the site of a coniferous forest, although trees of the original species gradually appear growing under the shade and protection of bushes, aspens, and other plants which first cover the burned ground. That fire is the principal cause of this change of forest composition is shown by the fact that, when the original trees are cut and fires are excluded, young trees of the same species appear at once. Many of the trees that grow in the regions where fires prevail have the power of reproducing themselves by root-suckers strongly developed. The soil loosened by fire, and enriched by the ashes of the destroyed forests, provides excellent seed-beds for the germination of the seeds of many annual and perennial plants. Hence these California burns often afford the best botanizing grounds in the State; and several otherwise rather local plants are appearing in such situations in much greater numbers and growing much more luxuriantly than they have ever been known to do before. It is not difficult, therefore, to imagine how great an influence this periodical burning of vast forest areas must have upon the composition and spread of the flora of the region.

A Hundred Miles an Hour.—New York Railroad Men publishes a symposium on the possibility of reaching a speed of a hundred miles an hour, and on the modifications in railroad appurtenances that will be required to promote such a result. Mr. J. D. Layng, of the Cleveland, Columbus, Cincinnati and Indianapolis Railroad, sees no more difficulty in raising speed to a hundred miles an hour than has been met in increasing it from thirty to sixty; and believes that it will be more difficult to get a track clear for the train than to develop a speed greater than now seems possible. Mr. George H. Thompson, of the New York Central and Hudson River Railroad, believes that a wide gauge will be necessary to secure the desired speed; "but, after the principles of railroading become better known, an ultimate railroad constructed and operated upon ultimate ideas will obtain. Forces now at work, partly physical, partly ethical, point to a broad gauge, say eight to ten feet. This gauge, outside of its adaptation to economical freight-work, will admit of large drivers, and consequent high-speed acceleration and low piston speeds." Further, Mr. Thompson believes, as a deduction from the doctrine of evolution relating to progress, that high speed will some day be in the usual order of things. Another general manager is hopeful as to high speed; but three other officers do not believe that a hundred miles an hour will be reached in this generation, if ever.

An Ant Mineralogist.—A curious coincidence is observed by M. A. Vercoutre between a statement of Pliny's and the habits of an American species of ant. The Roman naturalist relates that among a tribe in

northern India, called the Dardes, ants extract gold from mines, and adds that "metal which they have extracted during the winter, the Indians steal from them in summer when they have retired to their holes to escape the heat." The American ant (*Pogonomyrmex occidentalis*), which was studied by McCook in 1881, betrayed a similar disposition. When the colony have built their hill as a dome over their galleries, they cover the whole with small stones—fragments of rocks, fossils, minerals, etc., well fitted together in the style of mosaic, for which they go down, after the fashion of miners, to the depth of more than a yard below the surface. Now, as gold sometimes occurs in the region inhabited by these ants, we can easily suppose that their roofs will sometimes glisten with bits of that metal, which the natives might discover and take from them. The curious fact about the matter is, that these American ants are the only species known that correspond with Pliny's description. Had Pliny heard of them, and consequently of America; or did they once inhabit Asia also, and afterward disappear so completely as to be no longer known there? Or did Pliny repeat a traveler's tale, that has waited till this time for verification?

Mediæval Instruments of Torture.—A curious exhibition was held in London last fall of instruments of torture from the royal castle at Nuremberg which had been bought by the Earl of Shrewsbury and Talbot. With one or two exceptions, such as the "scavenger's daughter," no mediæval instrument of torture appeared to be unrepresented. The principal object of interest was the "iron maiden" (*eiserne Jungfrau*), which is probably the most terrible instrument of torture ever invented. It is the figure of a woman made of strong wood, bound with iron bands, opening with two doors to allow the prisoner to be placed inside. The interior is fitted with long, sharp iron spikes, which, when the doors are pressed to, forced their way into various parts of the victim's body and inflicted inexpressible agonies upon him till he died a lingering death. A trap-door was then opened in the base, and the body was allowed to fall into the moat or river below. The Scotch "maiden" of the sixteenth century was different from this, and was not an instrument of torture, but a kind of guillotine. Other objects were the racks; the "Spanish donkey," which cut the body into halves; the wheel on which malefactors were broken alive; the small lever with a sharp-toothed thumb and finger screw; the ducking-cage for bakers detected in giving short weight; the iron tongue-tearer, in the shape of a pair of tongs with screw; the Spanish "mouth-pear" or gag; and the yoke in which couples found guilty of acts of immorality were pilloried in the market-place. Of a different kind of interest are the copper mask worn by the judge of the Vehmgericht, the "drunkard's cloak and helmet," and carvings of Satan that were supposed to have been worshiped by witches. There were also manacles, body-rings, hand-screws, scourges, branding-irons, pillories, stretching-gallows, garters for torturing the legs, spiked collars, heavy chains for fastening prisoners to the wall, "mouth-openers" for slitting the tongues of blasphemers, sieves through which boiling water was poured on to the body, iron rings for fastening up criminals in public places, masks for the punishment of scolds and others, crucifixes which condemned criminals carried on their way to execution, iron mail chain gloves that were made hot before being put on, settles belonging to a torture-chamber, and many other things. A number of old prints accompanying the collection illustrated the application of some of these instruments.

Religious Ideas of Savages.—Having remarked that the conception of the Great Spirit of the North American Indians has been found not to be original with them, but suggested by the early Christian missionaries, Dr. E. B. Tylor proceeded, in a paper before the Anthropological Institute, to show that the mistaken attribution to barbaric races of beliefs really belonging to the cultivated world, as well as their development among these races under civilized influence, are due to several causes. Among them are direct adoption from foreign teachers; the exaggeration of genuine native deities of a lower order into a god or devil; the conversion of native words, denoting a whole class of minor spiritual beings, such as ghosts or demons, into individual names, alleged to be

those of a supreme good deity or of a rival evil deity. Detailed criticism of the names and descriptions of such beings in accounts of the religions of native tribes of America and Australasia was adduced, which gave in many cases direct proof of the beliefs in question being borrowed or developed under foreign influence. The problems involved in the discussion are of great difficulty, and the only hope for their full solution in many cases lies in the researches of anthropologists and philologists minutely acquainted with the culture and languages of the districts. Such researches should be carried out without delay, before important evidence, still available, has disappeared.

Character and the Voice.—Mr. Louis C. Elson remarks in the Boston Musical Herald on the effect of character or race upon the human voice as a subject that has never been well studied. It is a fairly well-known fact, he says, that certain kinds of voice prevail in certain countries: thus America produces many fine sopranos, Russia is the land of phenomenal bassos, and the sweet, high tenor must be sought chiefly in Spain; but it has not yet been quite determined as to whether climate, or diet and general mode of life, or actual distinction of race, is the cause of this definite distribution of vocal compass and timbre. The female voice in America is sharper and shriller than that of the Englishwoman or Frenchwoman, and this is especially noticeable in the conversational tone. The Englishwoman is more usually a full-toned alto than anything else; the Frenchwoman almost always is a mezzo-soprano. The peculiar style of singing a full falsetto, called *jodling*, which is chiefly heard in mountain districts, is another instance of race characteristics in vocal music. So perfectly is this singing done by the Tyrolese that the theory was held for a time that the throat of the Tyrolean might have some peculiar formation of its own, superinduced by peculiar diet and the drinking of snow-water. This has been shown by investigation to be erroneous; but since a similar style of singing is practiced in the Norwegian mountains, the Engadine, and other similar districts, it may be inferred that it results from a mode of calling the cattle, which is peculiarly high, characteristic, and penetrating, to which these people are accustomed from childhood. Peculiar types of voice may be found, upon investigation, to be rather the result of ages of peculiar usage, which finally produce traits that become hereditary, than of climate. The probability that diet may have some effect in the matter is mentioned. The voice of the American negro is distinguishable from that of the white singer, and here, perhaps, anatomy may afford a partial clew, for thick lips and a flat nose must influence the tone production in a certain degree. When these traits are absent, the tone of the colored singer is more akin to the ordinary standard of the singing of other races; and the author speaks of having heard some finely formed male Caffres sing, whose voices were not distinguishable from those of white singers. The loss of sight seems to have an appreciable effect on the voice, and, as a rule, one will find the intensely passionate character absent from the singing of the blind.

Sanitary Mistakes.—There is much in popular errors, says Dr. P. C. Redmondino, of San Diego, Cal., that helps to bring about our condition of physical degeneracy. For example, people look upon cold as their great and dreaded enemy, whereas cold—except in an extreme degree—does not and can not hurt any one primarily. To shut out the cold, which is harmless, they shut themselves in with ochlesitic poisons, as morbific and fatal in the end as the effects of alcohol and fusel oil. They have a vague idea that "catching cold" is to be avoided, but they have not the least idea of the lasting poison of ochlesis or in fomites. A man will give a friend a wide berth during the critical period of typhoid fever, but as soon as that period is passed he and his whole family will troop into the room, in blissful ignorance of the researches of Uffelmann and others into the wonderful tenacity of life possessed by the typhoid bacillus; or, so that they avoid the immediate breath of a consumptive, they live in fancied security. That this infection, as well as that of typhoid and other disease-germs, is longer lasting in a dark or north room, is not of any importance. The lady of the house, on the departure of her consumptive visitor, will at once draw the curtains and close the windows of her parlor that the

light and dust may not affect her carpets and *bric-à-brac*, perfectly unmindful that the care she bestows to protect these things is fraught with risk to the health and life of a son or daughter. She does not know, nor has she taken the pains to learn, nor has any one undertaken to instruct her, that the bacillus of such diseases as typhoid fever, diphtheria, phthisis, and most diseases which have a specific germ, can not exist and hold their identity in solar light and air, which, as has been demonstrated by Koch, kills them in from a few moments to a few hours, whereby no room is left for doubt that, by the construction of our houses and by the studied exclusion of light and air, we do most for the retention of these disease-germs, and at the same time contribute to the preservation of their vitality.

Earliest Use of the Mariner's Compass.—The history of the discovery of the mariner's compass by the Chinese is lost in their antiquities. It is supposed to have been accidental, in a province where there is much magnetic iron ore, from the observation that a needle made from that ore, when by any means it was caused to float on water, assumed a north and south direction. The earliest author who mentioned the "south-pointing needle" lived in the fourth century B. C. It probably came into use when the professors of fung shue or geomancy began to study landscape, about the eighth century of the Christian era. Their instrument was made of hard wood, about a foot wide, with a small well in the middle, in which a magnetized needle floated in water. On the compass were inscribed several concentric circles, as on the wooden horizons of our globes. They embraced the twelve double horns, the ten denary symbols, eight diagrams, and other marks. This compass was used in preparing a geomantic diagram of any spot where a house or tomb was to be constructed, so that the construction might not be upon an unlucky site, or planned in an unlucky manner. At the same time there was living a Chinese who had studied Hindoo astronomy, and was the imperial astronomer and also a Buddhist priest. He noticed that the needle did not point exactly north, but varied by 2° 5′. The variation went on increasing till a century later, or the ninth century. Shenkwa, writing in the eleventh century, mentions that any iron needle could be given polarity by rubbing it on a piece of loadstone. After this, in 1122, an ambassador to Corea described the use of the floating needle on board ship while he made the voyage. This is the earliest instance, by more than a century, of the use of the mariner's compass on board ship found in any book. At that time the needle was floated in water, supported by a piece of wood; but in the Ming dynasty some Japanese junks engaged in piracy were captured by Chinese, in which the needle of the compass was dry and raised upon a pivot. The Japanese had learned this from the Portuguese. The Chinese from that time also hung their compass-needles on a pivot.

An American Exhibition in Spain.—The Spanish Government is preparing to establish at Madrid, in honor of the fourth centennial of the discovery of America, an exhibition of every kind of American objects, so constituted as to give an idea of the civilizations of the American world, both previous to and coeval with the epoch of the discovery and the European conquests. For this purpose the commission solicits contributions of American objects illustrating prehistoric America—plans, models, and reproductions of drawings of cave dwellings, megalithic monuments, and lake dwellings, and of objects of all kinds of the palæolithic and neolithic ages, and of the bronze and copper ages. Of the historical period are wanted models or representations of buildings and architectural fragments, specimens of polychromatic architecture, representations of restored monuments, and works of fine art of every kind. In the department of industrial arts, etc., clothing and adornments of aboriginal uncivilized or only partly civilized Indians are asked for, implements of war of wood, copper, bronze, and iron; gold, silver, bone, and ivory jewels, necklaces, earrings, bracelets, etc.; pottery, household utensils, and furniture; tissues and textiles from which they are made; apparatus for manufacturing purposes; articles used in transportation; native documents; Indian portraits and effigies; models of Indian dwellings, crania, etc. Old maps, articles relating to cartography, whatever relates to

Columbus, etc., constitute another class; and the collection will be completed with representations of fine-art works, literary and scientific publications, and manuscripts, charts, and plans from the discovery to the middle of the eighteenth century. Prizes and diplomas are offered for the contributions.

The Royal Tombs of Uganda.—Dr. Carl Peters gives the following description of the more modern royal tombs of Uganda: "On approaching them from a distance the traveler thinks he sees pyramids before him, but in reality they are in the form of large cones, and are built of wood in Uganda fashion. On entering, the visitor finds himself in a dusky hall, supported by a row of columns. In the background of this hall is a painted curtain, before which are ranged the weapons and favorite movables of the deceased. On putting aside the curtain the dark area is entered, from which shafts and corridors have been excavated in the ground. In these passages textile stuffs, cowrie shells, and other articles of value, which in Uganda represent money, are heaped up. At the farthest extremity of these passages is deposited the coffin, with the embalmed corpse of the dead person. It appears that the regular procedure for preserving the corpse is by drying it, and swathing it tight in wrappings; but the Waganda also told me that they understood the art of preserving the body from decomposition by injections into the blood. In front of the curtain twelve girls watch day and night on behalf of the last one departed; at present, therefore, for Mtesa. From time to time all the great men of the land come to the dead man, with drums and fifes, to pay him a visit, as if he were alive."

Excess in Ornamentation.—In his book on the Planning of Ornament, Mr. Lewis F. Day recognizes as among the æsthetic faults of modern architecture its too free use of ornament without reference to its fitness to the other details of the structure, and relative neglect of proportion. A writer who timidly suggested lately that by a proper attention to proportion ornament might be economized, found himself out of fashion, as he doubtless apprehended. The Saturday Review enforces the precepts of the two authors, with a comparison of two buildings that stand near one another in London. Of one, the "front is composed of arches and columns — the arches of colored marbles, the columns of polished granite, the capitals of bronze, heavily gilt. Not far from it is another elevation, partly in brick and plaster, painted drab and wholly devoid of any ornament; yet the eye lingers lovingly on it. The proportions are like those of, say, one of Gray's odes, or one of Mendelssohn's songs without words. The whole façade cost perhaps seven or eight hundred pounds; but, then, it was designed by Wren. The bank front cost, at a moderate estimate, seventy or eighty thousand pounds, yet, because the architect, or, to speak more exactly, the builder, did not mix his design with a single ounce of brains, had not, in fact, so much brains to bestow upon it, all the money spent has produced so hideous a pile that one instinctively turns from it as one turns from a sudden glare or a street accident." Like contrasts may be found in almost any large town.

Amusements of Animals.—A writer in the London Spectator suggests as a logical order in which to consider some of the powers of enjoyment possessed by animals, without exaggerating or depreciating them, is to observe their development as the animal itself grows up. The faculty of amusement comes early in them. Many animals are aware of this, and make it part of their maternal duties to amuse their young. A ferret will play with her kittens, a cat with hers, and a dog with her puppies. A mare will play with her foal, though the writer from whom we quote has never seen a cow try to amuse her calf, nor any birds their young. If their mothers do not amuse them, the young ones invent games of their own. A flock of ewes and lambs were observed in the Isle of Wight in adjoining fields, separated by a fence with several gaps in it. "Follow my leader" was the game most in favor with this flock, the biggest lamb leading round the field and then jumping the gap, with all the others following in single file; any lambs that took the leap unusually well would give two or three more enthusiastic jumps out of sheer exuberant happi-

ness when it reached the other side. Another flock of lambs, confined in a straw-yard, had steeple-chases over a row of feeding-troughs stuffed with hay, right down the yard and back again. On a Yorkshire moor they have been seen to race, for a quarter of an hour, round a spring, and back to the ewes. Fawns play a kind of cross-touch from one side to the other, the "touch" in each case being given by the nose. Little pigs are also great at combined play, which generally takes the form of races. Emulation seems to form part of their amusement, for their races seem always to have the winning of the first place for their object, and are quite different from those combined rushes for food or causeless stampedes in which little pigs are wont to indulge. Racing is an amusement natural to some animals, and, being soon learned by others, becomes one of their most exciting pastimes. Many horses, and all racing-dogs, soon learn to be as keen at winning as public-school boys in a half-mile handicap. It is a common impulse with horses to pass, or at least to keep up with, any other horse in their company, and this instinct, developed by training, makes the professional race-horse eager to win. Animal enthusiasm for racing is well—the writer in the Spectator says best—seen in a dog-race. Birds especially delight in the free and fanciful use of their wings. There is all the difference possible between the flight of birds for "business" and pleasure; and many kinds on fine days will soar to vast heights for pleasure alone. In any comparison of the games and sports of animals with our own enjoyment of the same amusements, it must not be forgotten that imagination, the make-believe which enters into so much of the best play of children, is also the basis of much of the play of young animals. Watch a kitten, while you tap your fingers on the other side of a curtain or table-cloth, imitating the movements of a mouse running up and down. She knows it is not a mouse. But she enters into the spirit of the game, and goes through all the movements proper to the chase. Or perhaps she has a ball. If you set it in motion, so much the better—that helps "the make-believe." The ball is "alive," and she catches it, claws it, and half kills it, taking care all the while to keep it moving herself. The beautiful young lion, given by the Sultan of Sokoto to Queen Victoria last year, would play in exactly the same way with a large wooden ball, growling and setting up the crest, and pursuing the ball across the cage.

Durability of Oil Paintings.—Much time has been devoted by Mr. A. P. Laurie to the study of the means of insuring the durability of oil paintings. Some of the paintings of the old masters are still remarkably brilliant in coloring. A Van Eyck in the National Gallery is especially mentioned in M. Laurie's paper before the Society of Arts as having its colors all fairly well preserved, and a green—one of the most difficult of colors — wonderfully so. The quality is found not to reside in the pigments used, which were not superior to those of the present. It must, therefore, lie in the vehicle. It has been shown by Prof. Russell and Captain Abney that most fugitive pigments are permanent if protected from moisture, and a still larger number if protected from both air and moisture. If, therefore, we can obtain a vehicle which will really protect the particles of the pigment from moisture, we may use safely many pigments that are now regarded as fugitive. Mr. Laurie tested the qualities of linseed and walnut oils, the resins, and mixtures of oil and resins. His experiments showed that linseed oil, no matter how carefully refined, or in what way it is converted into boiled oil, can not be depended upon to protect a surface from moisture. Walnut oil proved no better. Solutions of resins in spirits of turpentine or benzol give as varnishes sufficient preservation from moisture for all practical purposes, but, forming a brittle and not very durable surface, are not fit to be used as mediums in place of oils. Eastlake's theory that the Flemish painters secured permanency by grinding their colors in oil and adding a little varnish, was tested and found not correct. No preparations of that kind experimented upon resisted the attacks of moisture; but a good mastic varnish was more efficient, and proved superior to any other substance tried. The use of copal or amber dissolved in spirit is also objectionable, because the varnish is difficult to remove. By using mastic, we have a varnish

which, while it affords the best protection to the picture from moisture, is easily removed and renewed. A source of danger to pictures to which not enough attention has been given is that which arises from the development of moisture by chemical action within the substance of the painting itself. An old medium of remarkable qualities has been recently discovered, concerning which nothing more is said at present, till its qualities are proved. Apparently the most durable surface that can be produced with modern mediums is that obtained with a mixture of copal oil varnish and linseed oil; and, until the proper medium is discovered, the best we can do is to paint our pictures with this medium and a carefully selected group of pigments, and then, as a further precaution, coat the pictures, when thoroughly dry, with a layer of mastic dissolved in turps (or turpentine).

Illustration of Customs.—The Pitt Rivers collection in the University Museum at Oxford is designed to illustrate the customs, life, and religious observances of primitive and semi-civilized races. The contents are arranged with a view to showing the various stages of development among different races and at different times, and to establishing direct relationship between the primitive and the modern types. The collection has also many European objects of antiquarian interest. Among them are specimens of the hornpipe, the instrument that gave its name to the dance performed to its music, and of the pipe and tambour used by the mummers at their performances. Among the exhibits relating to savage races is a collection of masks from Fiji, New Britain, and elsewhere, such as were worn at funerals by the male relatives of the deceased. In some cases the very skull of the dead man was made into masks, with the idea that he should assist at his own obsequies. The jew's-harp in many forms and developments—none, however, dating beyond the sixteenth century—has a place in the museum, together with a collection of primitive reed instruments, some of which were blown by the mouth and others by the nostrils. Of fire-kindling apparatus, the frictional fire-sticks of savages, the rather elaborate mechanical contrivance of the Brahman priests, and the apparatus used by the Vestal Virgins to kindle the sacred lamp if it should be extinguished, are shown.

Mediæval Guilds.—According to a paper in the Archæological Institute by the Rev. J. Hirst, on the Guilds of the Anglo-Saxon Monasteries, a regular system of communication was kept up between the various religious houses by means of messengers, who, being men of the world, were able to supply the news of passing events, even in the most distant countries. Other visitors to the abbeys were pilgrims, who were often admitted as brothers, and were thus enabled to participate in the benefits derived from the prayers of the community. From these sources no doubt the monkish chroniclers derived much of their information, which they so carefully recorded. The author said these ancient guilds threw a light on the origin, rapid increase, and organization of the English trade-guilds at a later period. Mr. J. T Micklethwaite pointed out a difference between these two sorts of guilds. The trade-guilds kept a common purse, whereas those attached to the monasteries did not; the absence also of the word guild in the Saxon manuscripts led him to believe that the trade-guilds were not derived from the monastic ones.

Spiders as Harpiots.—A curious account is given in Engineering of the way in which the accuracy of engineering work is often impaired by spiders and their webs. When plumb lines are sunk in shafts, the spiders sometimes attach their webs to them and draw them to one side. The accuracy of a certain work in the Hoosac Tunnel was destroyed until the lines, 1,028 feet long, were inclosed in cases. It has been suggested as a remedy to apply electricity to the lines so as to burn off the spider-threads. The writer in Engineering once found his vision when using the level distorted by the appearance of curved lines in its field. After consulting an oculist and paying his fees, he discovered that the whole trouble was caused by a little spider which had settled itself in the eye-glass of the telescope of the level. An electric-light metre, of the revolving fan type, was found doing imperfect work, as it recorded only a small fraction of the electricity that was known to be used. It was found that

a spider had entered the case through a screw-hole and spun a web in such a manner as to prevent the free use of the fans.

NOTES.

We published in the Monthly for June, 1886, a sketch, by Prof. David Starr Jordan, of the eminent early American naturalist C. S. Rafinesque, for which we were not able at the time to secure an authenticated portrait. We have since found such a portrait, which was published several years ago in Potter's American Monthly, and now have the privilege, by permission of Messrs. Potter & Co., of presenting it to our readers, as a supplement to Prof. Jordan's delightful sketch. It comes in opportunely at this time to supply the lack of the portraits of the Bartrams, of neither of whom have we been able to find an authenticated likeness. As the object most closely associated with the Bartrams, we give in connection with the sketch of them a view of the house built by the elder Bartram, as it appeared in 1887, from a photograph furnished us by Mr. Thomas Meehan.

A new star, not marked on any map, was observed February 1st in the constellation Auriga, slightly in advance of the star 26 of that constellation, and of about the same, or the sixth magnitude. It is described as yellowish, and somewhat fuzzy in appearance.

OBITUARY NOTES.

Dr. Thomas Sterry Hunt, a distinguished American geologist and chemist, died at the Park Avenue Hotel, in this city, February 11th, of mitral disease of the heart, in the sixty-sixth year of his age. A sketch of his life and scientific activity, and a portrait, were given in the Monthly for February, 1876. He retired from public professional life in 1878, but had made since then many important contributions to theoretical chemistry and geology. One of the organizers of the International Geological Congress, he was its first secretary, and was a vice-president at the meetings in Padua, 1878; Bologna, 1881; and London, 1888. He was a member of the International Juries at the Centennial Exhibition in 1876. Dr. Hunt had been in feeble health for many months previous to his death.

Sir George Biddell Airy, English Astronomer Royal from 1836 till 1881, died on January 2d, after a few months' illness, in the ninety-first year of his age. A sketch of his life and works up to that time, with a portrait, were given in The Popular Science Monthly for May, 1873. He after that made the preparations for the equipment of the British expedition for the observation of the transit of Venus of 1874, a subject on which he had been engaged since 1836. He retired from his office in the Greenwich Observatory in 1881, after forty-five years of service.

M. Émile de Laveleye, the eminent Belgian economist and publicist, died at Liége, early in January, of pneumonia, following influenza, just after the publication of his latest work, Government in Democracy. He was born in Bruges in 1822, studied law in the University of Ghent, and engaged in historical and philological labors, and afterward in works on political economy and kindred sciences, which gave him a world-wide reputation. In 1864 he was appointed Professor of Political Economy in the University of Liége. His principal works were on the Rural Economy of Belgium and of Holland, on Property and its Primitive Forms, and Natural Laws and the Object of Political Economy. He was the most conspicuous advocate of bimetallism.

According to the Academy, the death of the Duke of Devonshire, in December, 1891, was a greater loss to the learned world than (directly) to politics or society. The duke had been intimately associated with academical affairs ever since he took his degree at Cambridge in 1829. "The Cavendish Laboratory at Cambridge bears witness to his munificence, while science acknowledges no less gratitude to him for serving as chairman of the Royal Commission on Scientific Instruction and the Advancement of Science."

Prof. John Couch Adams, the English astronomer and mathematician, who shares with Leverrier the honor of having predicted the place where the planet Neptune would be found, has recently died. He was the son of a farmer, and was born near Bodmin, Cornwall, in 1818. He began his investigations of the irregularities in the motions of Uranus in 1841, and completed them as early as Leverrier did his, but suffered himself to be anticipated in the publication. In 1858 he succeeded the late Dean Peacocke as Lowndean Professor of Astronomy at Cambridge.

The death is announced of Colonel James Augustus Grant, a famous African explorer. He was the son of a Scottish clergyman and was born in 1827; served in the war of the Indian mutiny; accompanied the Abyssinian Expedition in 1868 as a member of the Intelligence Department; and in 1860 to 1863, with Captain Speke, explored the sources of the Nile and discovered the Victoria Nyanza. He described this expedition in the Journal of the Royal Geographical Society, and its botany in those of the Linnæan Society; and published in 1874 a supplementary account of the expedition, of which a joint account by the two explorers had already appeared. It was entitled A Walk across Africa. He received medals from the Royal Geographical Society, the Pope, and King Victor Emanuel.

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FINANCIAL CONDITION, JUNE 30, 1891,

OF THE

NEW YORK LIFE INSURANCE COMPANY,

WILLIAM H. BEERS, President.

INSURANCE DEPARTMENT OF THE STATE OF NEW YORK,
ALBANY, N. Y., *January* 19, 1892.

Pursuant to statute, and by request of the Company's Board of Trustees, the undersigned, Superintendent of the Insurance Department of the State of New York, has caused an examination of the conditions and affairs of the NEW YORK LIFE INSURANCE COMPANY to be made by the Deputy Superintendent of this Department. * * * * * * * * * * * *

This examination was made as of June 30, 1891, and on that date we find that its assets and liabilities were as follows:

ASSETS.

1.	Appraised value of real estate owned by the Company as per Exhibit 1		$13,225,038 59
2.	Loans on bond and mortgage (first liens) on real estate, as per Exhibit 2		20,825,483 64
3.	Loans secured by pledge of bonds, stocks, or other marketable collaterals, as per Exhibit 3		3,509,500 00
4.	Premium notes, loans or liens on policies in force, the reserve on each of such policies being in excess of all indebtedness thereon, as per Exhibit 4,		438,868 00
5.	Market value of bonds, stocks, and securities owned absolutely, as per Exhibit 5		75,016,949 92
6.	Cash in Company's office		14,092 66
7.	Cash in bank, except fixed deposits in foreign countries, included in Item 5,		2,610,094 52
8.	Interest due and accrued on bonds and mortgages		427,210 31
9.	Gross premiums due and unreported on policies in force	$3,682,577	
10.	Gross deferred premiums on policies in force	1,964,648	
11.	Annuity premiums uncollected	157,091	
12.	Total	$5,804,316	
13.	Deduct 20 per cent loading on above gross amount	1,160,863	
14.	Net amount of uncollected and deferred premiums		4,643,453 00
	Total assets		**$120,710,690 64**

LIABILITIES AND SURPLUS.

1.	Net present value of all the outstanding policies in force on the 30th day of June, 1891, computed according to the combined experience table of mortality with 4 per cent interest	105,010,324 00
2.	Deduct net value of risks of this Company re-insured in other solvent companies	402,120 00
3.	Net re-insurance reserve	$104,608,104 00
4.	Claims for matured endowments due and unpaid	39,019 00
5.	Claims for death-losses unpaid [proofs and vouchers not complete]	990,507 00
6.	Amounts due and unpaid on annuity claims	146,550 81
7.	Liability on account of lapsed policies	138,481 00
8.	Premiums paid in advance	79,353 00
9.	**Total liabilities on policy-holders' account**	**$106,002,014 81**
10.	**Gross surplus on policy-holders' account**	**14,708,675 83**
11.	Total liabilities	$120,710,690 64
12.	Estimated surplus, accrued on Tontine or other policies, the profits upon which are especially reserved for that class of policies	8,670,539 50
13.	Estimated surplus accrued on all other policies	6,038,136 33

* * * * * * * * * * * * * * * * * * * *

Signed, JAMES F. PIERCE, *Superintendent.*

MICHAEL SHANNON, *Deputy Superintendent.*

The above total surplus of $14,708,675.83 is exclusive of any amounts due from Agents, and is larger than the surplus of any other purely mutual life insurance company in the world.

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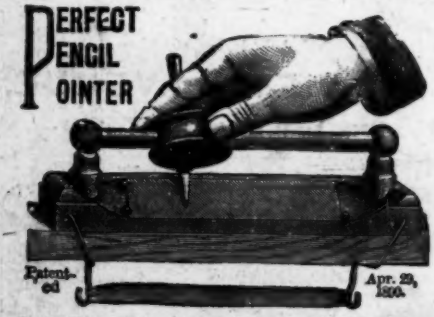

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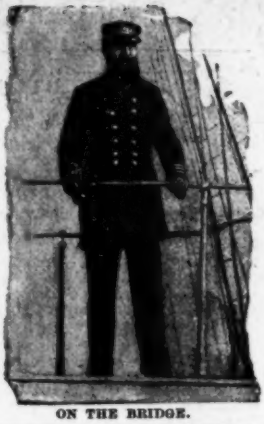

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FORTY-SEVENTH ANNUAL REPORT OF THE

NEW YORK LIFE INS. CO.

OFFICE, Nos. 346 & 348 BROADWAY, NEW YORK.

JANUARY 1, 1892.

ASSETS.

Real Estate, including all Office Buildings and property purchased under foreclosure	$12,428,247 15	
Stocks and Bonds owned	77,647,663 40	
Bonds and Mortgages	21,456,233 56	
Loans secured by collaterals (market value of Securities held as collateral, $5,879,357)	4,551,000 00	
Premium Loans on existing Policies (the Reserve on these Policies, included in Liabilities, amounts to over $2,000,000)	521,700 28	
Cash in Office and in Banks and Trust Companies	6,070,942 27	
Interest and Rents due and accrued	565,037 81	
Net amount of uncollected and deferred Premiums	2,756,466 34	
TOTAL ASSETS		**$125,947,290 81**

LIABILITIES.

Reserve, or Value of outstanding Policies, at Actuaries' 4 per cent, as per Certificate of New York State Insurance Department	$108,439,935 00	
Special Reserve on Annuities, in excess of State Standard	968,921 00	
Approved Losses in course of payment	652,272 88	
Reported Losses awaiting proof, etc	544,895 01	
Matured Endowments due and unpaid (claims not presented)	47,993 71	
Annuities due and unpaid (claims not presented)	28,060 68	
Premiums paid in advance	52,696 94	
Trust Deposit, held for account of beneficiaries under terms of Policies	46,192 50	
Total Liabilities		**$110,806,267 50**
Surplus, being the same amount which will be shown to be the Company's Surplus by the Annual Report of the New York State Insurance Department as of December 1, 1891		$15,141,023 31
Estimated Surplus accrued on Tontine Policies	$9,737,121 00	
" " " " all other "	5,383,902 31	—$15,141,023 31

INCOME.

Premiums received on Insurance Policies	$23,554,996 97	
Premiums paid by Dividends and by Surrender Values	1,430 607 00	
Premiums received for Annuities	1,304,120 81	
	$26,289,724 78	
Deduct amount paid for re-insurance	33,449 38	
Total Premium Income		$26,256,275 40
Interest and Rents received		5,548,727 08
Trust Deposit received and held for account of beneficiaries under the terms of Policies		49,192 50
Total Income		**$31,854,194 98**

DISBURSEMENTS.

Losses paid	$6,087,820 70	
Endowments matured and discounted, paid	1,088,795 11	
Annuities paid	1,371,634 28	
Dividends paid	1,860,340 74	
Paid for Purchased Policies	1,710,208 36	
Surrender Values applied as Premiums	706,081 87	
Purchased Reversions	465,810 04	
Instalment paid on Trust Deposit	3,080 00	
Total Amount paid to Policy-holders	$12,071,490 88	
Commissions and Brokerages to Agents	3,918,142 69	
Agency Expenses	931,810 08	
Physicians' Fees, Advertising, Stationery, and Printing	618,803 62	
Salaries	500,578 18	
Law and Office Expenses, Rents, and Repairs and Care of Real Estate	533,113 87	
Taxes in the State of New York and other States	284,150 60	
Total Disbursements		**$19,458,089 90**

NOTE AS TO SURPLUS.

The Surplus on January 1, 1892, according to the valuations of Securities made by the Insurance Department in its recent examination, and according to the State Standard of Policy Reserve, was		$17,049,320 13
But the Trustees have deemed it for the best interests of the policy-holders to apply a part thereof in the reduction of values of several Office Buildings, such reduction amounting to	$919,375 82	
The Trustees have also deemed it best to increase the Reserve held for annuitants above the sum fixed by the State standard of valuation, such excess being	988,921 00	—$1,908,296 82
		$15,141,023 31

Number of Policies issued during 1891, 52,746. Total number of Policies in force Jan. 1, 1892, 193,452.

New Insurance, $152,664,982. Amount at Risk, $614,824,713.

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